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UNIVERSITY OF MINNESOTA

An Open Letter to Mr. Duerksen

November 16, 1946

MR. G. H. DUERKSEN
Personnel Manager
Research Department
Phillips Petroleum Company
Bartlesville, Oklahoma

Dear Mr. Duerksen:

The Industrial Coordinator of our College of Engineering tells me that you visited the University on the twelfth in order to interview senior students about going to work for your corporation after graduation. I trust that you discovered a number who were interested and who met your requirements. I am sorry that I had no opportunity to see you.

But that is not what's on my mind today. What I am suggesting today is that you become a member of the American Society for Engineering Education. No, this is no ordinary membership push, no "all you guys bring in a member" sort of thing. There are much better reasons for your joining the Society:

We engineering educators are trying hard to do a good job. Of course, you can point out certain deficiencies in engineering education. We, who are close to the work, can point out many more. But we aim to correct these deficiencies and to keep ourselves adjusted to rapid developments in the engineering sciences, and to constant improvements in the practices of the industries.

It's not an easy assignment. We have to have your advice and assistance, you who hire our graduates and put them to work. But this advice and assistance must be based on close contact between us. Every once in a while some national business or industrial figure takes three or four pages in *Colliers* or the *Post* to lecture us about the shortcomings of our graduates. Very often these lectures are of no practical value. We read the articles with interest but soon discover that the mogul doesn't know any more about education than we know about his business. Before his opinions can be of any use, he and we must first know and understand each other, and what we are respectively doing and how we are doing it.

You will insist, of course, that there is contact between industry and education; that Mr. Sloan and Dr. Compton work closely together, for instance. They doubtless do, but there has been precious little contact down the line, between Arthur Breslin, who has to do with electrical instruments in General Motors Research, and Professor Bennett, who teaches electrical measurements at M. I. T. I recognize that there are many research and personnel agreements between industries and schools, but each agreement involves no more than one or two men on either side of the fence. The average business or industrial man hides

away in his office or plant, and the average college man in his laboratory (or ivory tower). Membership in the American Society for Engineering Education is the most effective kind of contact between the two.

Another good reason why I think you should join the Society is that the annual and regional meetings provide for you an excellent and concentrated audience. You have an important message for the engineering educators. In the meetings you can stand up on the floor—if they don't put you on the program—and tell your story once and for all to all the educators; or to almost all, because the educators make it their business to attend the meetings. That is efficient and economical. If you are not a member you wear yourself out saying the same thing over and over again in fifty or seventy-five colleges which you visit in turn. At the meetings the professors are relaxed and receptive; at home they are too busy to listen to you. At the meetings you can influence great numbers of the educators; in your travels you encounter only two or three in each institution.

Finally, as a recruiting or personnel official, you are an advance agent or liaison man between industry and schools, and nobody in the industries is a more logical or natural candidate for membership in the Society than you are.

Accordingly, I am enclosing an application for membership which we have made out in your name, and which the Industrial Coordinator and I have endorsed. You clearly qualify for membership, and so does every personnel official I can remember who has visited the University in recent years. Please send the application to Dr. Bishop, Secretary of the Society, in the stamped and addressed envelope which is likewise enclosed. He will appreciate a check in advance for the year's dues. The amount—believe it or not—is five dollars; a proper expense account item, I should think. There is no admission fee.

And while I am at it, I shall suggest to Mr. Hunt, our Industrial Coordinator, that he keep a supply of applications for membership on his desk, and invite industrial representatives who see him to become members. He might quite properly, in my opinion, show preference to personnel officials who are members or who have made application for membership. For example, he might permit only members and applicants to meet those of our senior students who are really outstanding; the kind who make your eyes sparkle two minutes after you begin talking to them.

And that suggests the thought that all our engineering colleges might recruit industrial representatives for the Society while the representatives recruit seniors for their industries. I have still another idea. I have been told off to produce an editorial for the JOURNAL OF ENGINEERING EDUCATION not later than November 30. It seems to me I have an editorial right here. Why not? I shall strike off a copy, send it to Dr. Bishop and ask him to print it as an open letter. You and your company will get a little publicity you weren't thinking about.

Anyhow, I hope you will visit the University again next year, or sooner if you can, and that you will become an interested and active member of the American Society for Engineering Education.

Sincerely,

C. J. FREUND,
Dean

Beautiful Minnesota Awaits You

The University of Minnesota, scene of the 1947 annual meeting of the American Society for Engineering Education next June (18–21), is situated on the picturesque eastern bluffs of the Mississippi river near historic St. Anthony Falls in beautiful Minneapolis, the City of Lakes.

Now one of the largest educational institutions in the world and recognized as one of the most progressive, the University of Minnesota was founded in 1851, by the Minnesota Territorial Legislature. Reorganized in 1869, the University dates its actual development from that year.

Although the central seat of the University is the main campus in Minneapolis, it carries on its work in many parts of the state and serves all sections of Minnesota.

At University Farm, also known as the farm campus, two miles from the main campus and in nearby St. Paul, are the College of Agriculture, Forestry and Home Economics, the Central School of Agriculture and the headquarters of the Agricultural Experiment Station. Other, smaller branches of the University are distributed throughout the state.

The main campus of the University in Minneapolis embraces an area of 140 acres and includes 104 buildings. The University Farm in St. Paul covers 689 acres and has 167 buildings. An inter-campus trolley links the two campuses.

Midway between the Minneapolis and St. Paul campuses is University Village, an extensive settlement of trailers, pre-fabricated houses and quonset huts erected by the University to house married veteran students and their families.

With a fall quarter registration of 27,389 full-time collegiate students, 5,582 in the Institute of Technology alone, the University of Minnesota has reached an all-time enrollment high this year. Of these 27,389 full-time students, 16,428 are veterans of World War II, including 680 women veterans.

Men outnumber women students at the University of Minnesota this year by a ratio of almost three to one with 19,972 men enrolled as compared with 7,417 women.

In addition to its collegiate enrollment of 27,389, the University of Minnesota is training 14,541 students who are enrolled in evening classes, the several schools of agriculture, correspondence study, University high school and other University programs. Counting these non-collegiate students, the University has an overall enrollment of 41,930.

The staff of the University, which has been increasing steadily this year to meet the demands of the record enrollment numbered, at last count, 2,678 academic members and 3,642 civil service employees, a total of 6,320. On a fulltime equivalent basis, the staff includes 1,761 academic members and 1,980 civil service employees, a total of 3,741.

JAMES LEWIS MORRILL, PRESIDENT,
UNIVERSITY OF MINNESOTA

AERIAL VIEW ST. ANTHONY FALLS, MINNEAPOLIS

University of Minnesota's Hydraulic Laboratory at right center (white structure).
Courtesy of the *Minneapolis Journal*

CENTER FOR CONTINUATION STUDY, UNIVERSITY OF MINNESOTA

Many famous educators and scientists are members of the University of Minnesota staff. Who's Who in America for 1946–47 includes 237 names of Minnesota's faculty men and women.

Administrative head of the University is Dr. J. L. Morrill, eighth president of the institution, who assumed office July 1, 1945, and was inaugurated formally on April 25, 1946. Governing body of the University is its Board of Regents, consisting of 12 members, some of whom are elected by the state legislature and some appointed by the governor of the state for six-year terms.

Dr. Morrill, a native of Marion, O., was graduated from Ohio State University in 1913, has been in educational work since 1919, when he left an editorial position with the Cleveland (O.) Press to become alumni secretary and editor of Ohio State University.

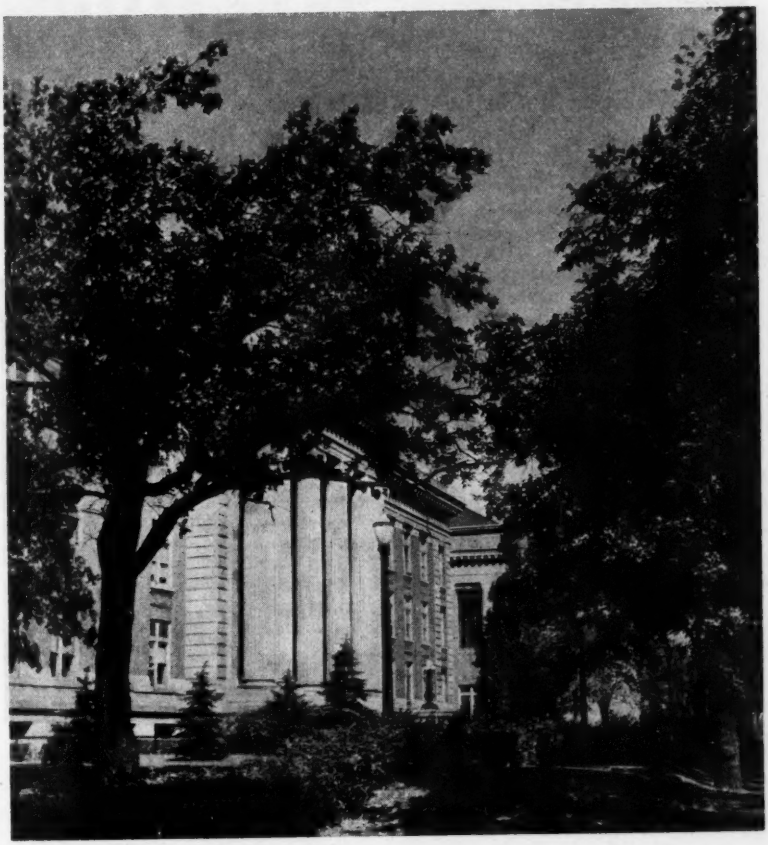
Subsequently, he served in teaching positions in journalism and education, became junior dean of the college of education. In 1932, he became vice president of Ohio State University, a position which he held until 1941, when he was named president of the University of Wyoming. He holds the LL.D. degree from Miami University, Oxford, O., and from Ohio State University.

The University is the acknowledged cultural hub of Minnesota and the Northwest. Many thousands of people from throughout the Northwest visit the Minneapolis campus each year for

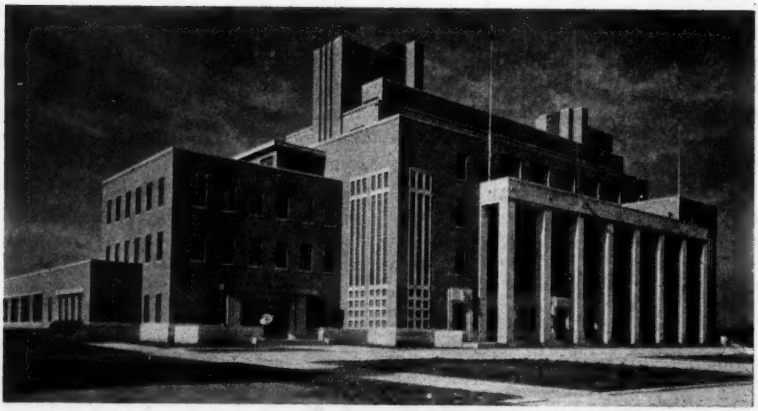
concerts, lectures, art displays, debates on topics of current interest, student plays and other varied activities. Northrop Memorial auditorium, in the center of the campus, is the home of the famous Minneapolis Symphony orchestra, directed by Dimitri Mitropoulos.

Through its many publications and the radio programs of its 5,000-watt station, KUOM, the University provides further avenues of instruction and entertainment to the people of the Northwest.

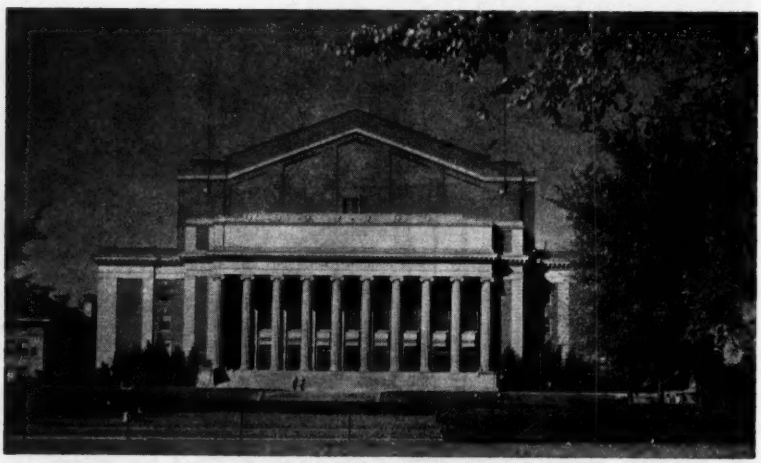
Minnesota's Golden Gophers, coached by the inimitable Bernie Bierman, have been rugged, smart, smashing football teams down through the years. More than 50,000 fans crowd the huge, red brick Memorial Stadium on crisp fall Saturday afternoons when the Gophers are playing at home. The



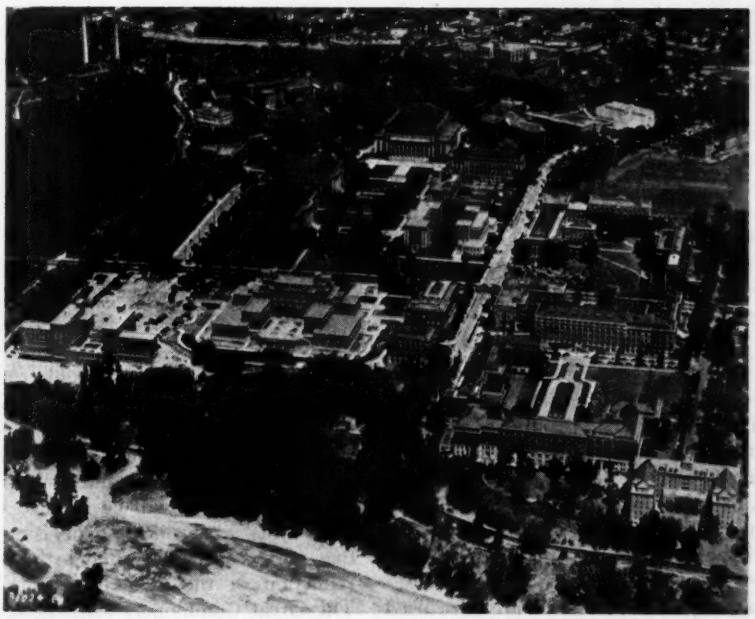
School of Chemistry Building and Library, University of Minnesota
These buildings face the Mall.



COFFMAN MEMORIAL UNION, UNIVERSITY OF MINNESOTA



NORTHROP MEMORIAL AUDITORIUM, UNIVERSITY OF MINNESOTA
Home of the Minneapolis Symphony Orchestra—Seats more than 5,000



AERIAL VIEW, UNIVERSITY OF MINNESOTA CAMPUS, ON BLUFFS OF THE MISSISSIPPI RIVER (UPPER LEFT)

University of Minnesota also turns out formidable basketball, hockey, baseball and track teams which also provide many hours of exciting enjoyment for student and non-student fans alike.

Members of the American Society for Engineering Education next summer will see the University of Minnesota's campus at the height of its beauty. Fishermen will find some of the nation's finest angling in Minnesota's famous lakes and streams just a short distance from the campus. And . . . don't forget your swimming suits.

Valuation of Public Utilities: Is it Possible to Reconcile Original-Cost and Reproduction-New Theories?*

By A. S. LANGSDORF

Dean, Schools of Engineering and Architecture, Washington University

One does not have to delve very deeply into the extensive literature on valuation of public utilities to discover that the major controversial issue hinges on the question whether the "fair value" allowed for rate-making purposes should be based upon the original-cost or upon the reproduction-new theory. The terms "original-cost" and "reproduction-new" are here used in a broad sense to distinguish between the two possible extremes, omitting the numerous modifications of both terms that are frequently invoked. One conclusion that emerges from a study of testimony in rate cases, and in court decisions based thereon, is that in general the two contending parties seem to assume that there is no middle ground between these extremes that permits the assignment of due weight to both of them at the same time. So far as the writer has been able to discover, no one has yet formulated a set of basic principles that might serve as a basis for logical thinking in this field, to say nothing of setting up a formula applicable to all cases.

Those whose memories go back to 1907 will remember that William Jennings Bryan, in announcing his candidacy for the Presidency, stated that the paramount issue of the campaign would be a downward revision of the valuation of the railroads in the interest of decreased rates. It will be recalled that there was a business depression in that period which resulted in a sharp reduction in the general price level. The Great Commoner, with the interests of the general public in mind, wanted to take advantage of that condition by assigning to the railroads the reduced valuations that would have represented their reproduction cost at that time. The railroads naturally objected on the ground that their actual investments were greater than the reproduction cost at that time. It was that controversy which initiated the long and costly series of railroad valuations undertaken by the Interstate Commerce Commission. In later years, particularly in the 1920's, when prices had risen to what seemed to be a permanently high plateau following the first World War, the utilities fought for, and the courts sustained, valuations based upon the high reproduction cost brought about by the soaring price level, while at the same time the representatives of the public reversed Mr. Bryan's attitude and became firm sup-

* Presented at the Conference on Engineering Economy, S.P.E.E. meeting, St. Louis, June 20–23, 1946.

porters of the relatively lower original-cost valuation. While it is true that the latest Supreme Court decision (in the Hope Natural Gas case) took a stand in favor of the original-cost theory, reversing a trend in support of reproduction-new that characterized a considerable number of previous cases, the fact remains that the great majority of utility rate charges are still based upon the high reproduction values allowed in years of high prices. It is an interesting fact that the financial interests which for so long insisted on reproduction-new as the proper basis for valuation were, perhaps unwittingly, accepting the ideas of Karl Marx, who wrote that "the socially necessary value of a commodity is the cost of reproducing it."

The question that naturally arises in the mind of a disinterested student is this—How much validity can be attributed to either of these extreme theories, if a change in the price level can so quickly convert the proponents of one extreme into an equally ardent supporter of the other? Cold and impartial logic compels the conclusion that a theory which is regarded by one party as perfectly correct at a time of rising prices, and completely wrong at a time of falling prices, is not a valid theory at all. It must be concluded that the partisanship of the utilities and of the public, always on opposite sides, but with the sides interchangeable as conditions change, reflects nothing more or less than the immediate self-interest of both parties. It would appear, therefore, that the whole problem of valuing utilities in a way that is fair both to the utilities and to the public must be based upon principles that are independent of fluctuations in price levels.

The importance of the dollar value assigned to the physical property of a given utility arises from the fact that the product of this amount by the agreed per cent rate of return determines one component of the annual sum which the utility is entitled to charge its customers for services rendered; the other components of the annual earning cover all legitimate operating expenses, including taxes and depreciation. The breakdown of this total charge into the rates charged for different types of service need not here concern us. It is sufficient for present purposes to point out that the overall annual charge for service is of primary importance to the public, while the net return on valuation is of primary importance to the owners of the utilities stocks and bonds; to them, the amount paid out for operating expenses and taxes represents merely "trading dollars," though the uninitiated might conclude from the occasional noisy protests against alleged excessive taxation of the utilities that they were themselves paying the taxes instead of merely collecting them from the consumers and handing them over to the public treasury. Self-interest on the part of the public calls for the lowest possible overall charge for efficient service, therefore for the lowest possible valuation. Self-interest on the part of the owners of the utility calls for the highest possible valuation, since it is the legitimate return on this valuation that sticks to their ribs. There is one aspect of this insistence by the utilities in favor of high valuation (and therefore upon the reproduction-new theory when the price level is high) that deserves more attention than it seems to have received, though it was forcefully pointed out by Commissioner Eastman of the Interstate Commerce Commission in the famous St. Louis and O'Fallon Railway case. It is that the larger

return on an inflated valuation goes to the holders of common stock only, not to the owners of preferred stock and bonds, since the latter securities carry a fixed return on a fixed principal sum. For example, suppose that a property which actually cost P dollars is valued, because of inflated prices, at 1.5 P dollars; and suppose that this capital sum is divided equally between common stock, preferred stock, and bonds. If the rate of return is assumed to be p per cent on all securities, the original return to common stockholders would have been $\frac{1}{3}pP$, whereas under the increased valuation it would be $(\frac{3}{2}pP - \frac{2}{3}pP) = \frac{5}{6}pP$, or 2.5 times the original return. This result means that the purchasing power of the dividends paid to owners of common stock has not only been maintained, but has been decidedly increased, whereas the other investors have suffered a decline in purchasing power. Just why the owners of common stock should thus be awarded preferential status as to purchasing power when all others are adversely affected has never been adequately explained, and on its face it is indefensible.

Throughout the long series of court decisions which, until the Hope Natural Gas case, established the primacy of the reproduction-new theory, there is discernible the underlying philosophy that a privately owned public utility partakes of the nature of private business. The yard-stick for determining fair valuation (always assuming a rising price level) appears to have been the procedures that private business would adopt under such circumstances. Nowhere except in the history of the Tennessee Valley Authority does there appear any material evidence that the proper basis of comparison is what would happen under like conditions to an *equivalent publicly owned and efficiently operated utility*. It seems to this writer that the proper yard-stick is the publicly owned utility, not private business, for on what other ground can the public regulation of utilities be soundly based? The question whether a given set of service charges is too high or too low can only be determined by comparing them with what an equivalent service, publicly owned, would have cost.

Suppose we digress for a moment to take a look at the basis for proper service charges by a publicly owned utility that will be supposed to have been soundly financed, honestly built, and efficiently managed. The original (judicious) investment would be represented, say, by bonds having a life reasonably concurrent with the life expectancy of the propertly itself. The service charges would then have to be sufficient to pay interest on the bonds to their maturity, to set up a sinking fund for the redemption of the bonds, and to cover all legitimate operating costs; whether or not taxes are assessed against the property is not particularly important so far as the argument is concerned. If taxes are paid, they appear as an extra charge to the customers, thereby relieving the non-customers from this burden; if they are not included, the community as a whole must make up the amount thus waived, to meet the community budget. The really essential point is that interest would have to be paid on the original investment throughout the life of that investment, notwithstanding the fact that the accumulations in the sinking fund are steadily increasing until the original investment has been recovered. The purpose of this sinking fund is not primarily to redeem the bonds, but to insure indefinite continuity of service by replacement of the fully depreciated

property against which new bonds may then be issued. It may be objected that this analysis is an over-simplification; that the bonds do not all run concurrently with the property as a whole, and that different parts of the property have greatly different life expectancies. Granted that this is so, the fact remains that the short-time bonds tend to balance out the short-lived portions of property, which, when worn out, have to be replaced by the equivalent of a new capitalization if continuity of service is to be maintained. When the matter is looked at from this point of view, the sinking fund is seen to be nothing but a depreciation reserve for necessary renewal of worn out parts.

If this general idea makes sense, it is immediately applicable to the privately owned utility, and leads to the conclusion that the return on the original (judicious) investment should be maintained throughout the useful life of the property upon which the valuation is based. It follows that it is fallacious to base the valuation upon the physically depreciated condition of the property, so long as that property is usefully employed. Since depreciation occurs more or less gradually on a system-wide basis, or at any rate by a succession of discontinuous jumps, valuation based on cost-less-depreciation should theoretically be made at such frequent intervals as to be a nuisance to all concerned, to say nothing of the great cost of such an undertaking. Such periodic valuations are enough of a headache to insure their occurrence at relatively long intervals, but even so the principle underlying them is wrong provided that the depreciation reserve is properly handled, and provided that the partially deteriorated property functions efficiently.

The mention of depreciation reserves leads naturally to a consideration of the meaning of depreciation itself. Physical objects ultimately wear out, usually slowly at first, then more and more rapidly; or they pass suddenly out of the picture because of obsolescence, which may be described, or possibly defined, as socially accelerated depreciation. In either case, the physical realities of the situation are easily understood; the difficulties enter when accounting procedures are introduced.

Consider the diagram, Fig. 1, in which OP represents the initial value of an object, nS its scrap value after a

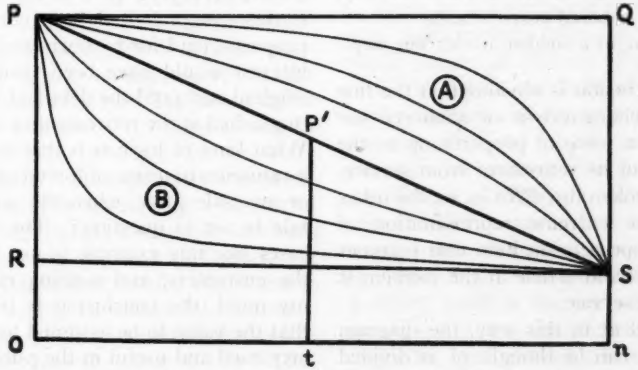


FIG. 1

time *On* years. In terms of the straight-line theory of depreciation, the loss of value is assumed to occur linearly, so that the residual value at any time *t* is indicated by the ordinate *tP'*. Under the sinking-fund theory, the change from initial to scrap value is represented by some one of the family of curves in region *A*, which change from the linear form *PS* to the form *PQS* as the assumed interest rate changes from zero to infinity. On the other hand, if the Mathieson method is used, the residual value is represented by the family of curves in region *B*, which change from the linear form *PS* to the form *PRS* as the interest rate changes from zero to infinity. It is convenient to focus attention upon the two extreme types of depreciated value, namely *PQS* and *PRS*.

The broken line *PQS* indicates that the residual value remains unaltered at its original amount until the very moment when the physical item becomes scrap; it is, therefore, the graphical representation of Oliver Wendell Holmes' famous poem which runs

"Have you heard of the wonderful one-hoss-shay,
That was built in such a wonderful way.
It ran a hundred years to a day
And then, of a sudden, it—ah, but stay."

The conclusion is obvious that the line *PQS* is characteristic of unaltered *use* value of a piece of property up to the moment of its retirement from service.

The broken line *PRS* is, on the other hand, the extreme representation of what happens to an item that becomes a second-hand article at the moment it goes into service.

Looked at in this way, the diagram of Fig. 1 can be thought of as divided into two zones, *A* and *B*, the former indicating, in general, use values, the latter second-hand values. This approach to the meaning of depreciated value serves to throw into high relief the real issue involved in much of the expert testimony offered at hearings before rate-making commissions. In one such case that comes to mind, one of the items that resulted in pages of testimony was concerned with the value to be assigned to a gas tank. The engineer testifying for the utility insisted that the value was as high, or even higher, than its original cost. The attorney for the community that was seeking reduced rates for gas insisted that the paint on the tank had lost its lustre, that the paint had blistered and peeled off, and that the steel shell was rusty. The two men were talking about wholly different considerations; the engineer was certain that the tank was functioning perfectly, that it did not leak, and that so far as the customers were concerned they were getting gas just as well as if the tank were bright and shiny; the attorney was thinking of a forced sale price on a second-hand piece of property. It is precisely this point which emphasizes the contention that the yardstick of comparison should be a publicly owned property; for it is obvious that if this gas tank had been community property, paid for by borrowed money, interest would have been paid on the original cost until the debt had been extinguished at the retirement of the tank. What kind of logic is it that insists on a valuation in terms of forced sale price, or any sale price, when the issue of a sale is not in question? The issue in cases like this example is use value to the customers, and nothing else. To my mind, the conclusion is inevitable that the value to be assigned to a property used and useful in the public service is its undepreciated original cost

(or more properly, its judicious investment value).

But if original-cost, or judicious investment, theory is adopted as the proper basis for valuation, it does not follow that reproduction costs, whether they be higher or lower than original costs, can be disregarded. When one faces this problem squarely in a search for a logical method for giving due weight to reproduction costs, the solution will be seen to depend upon the consideration that the service to be rendered by the utility must be indefinitely continuous. Replacements or renewals of physical property must be made as and when needed, and at prices that prevail at the time of replacement or renewal. The only logical solution of the problem is to set aside in the depreciation reserve account annual sums that are increased or decreased as the price level for the items in question rises or falls. If this were done, changes in the reproduction costs would be automatically allowed for.

It is obvious, of course, that the determination of the proper depreciation allowance based on this idea is neither simple nor easy. But fundamentally the procedures that would have to be followed would be substantially analogous to those of life insurance companies in setting up the reserves to take care of death claims. The depreciation reserve account of a utility should in fact be a reserve to pay for the death of property. This means that depreciation should be allowed for by actuarial calculations based on mortality statistics for inanimate physical appliances. If it is objected that sudden obsolescence cannot easily be taken into account, it may be said in reply that unforseeable epidemics play the same role in life insurance affairs that unforseen obsolescence does in the operation of public utilities. In either case, the extra cost of an epidemic or the extra cost of obsolescence, is logically a fair charge against the public. In life insurance practice, the large payments of death claims caused by an epidemic are made up by a reduction of dividends, equivalent to an increase in premiums. In the same manner, large outlays to make up for capital losses through obsolescence should be compensated by upward revision of depreciation allowances. But it follows, of course, that under the conditions here outlined, the depreciation reserve must be regarded as a trust fund, never to be tapped for dividend payments. It is believed that procedures based upon these ideas would give proper recognition both to the original-cost theory and to the reproduction-new theory. There is no doubt that the method suggested removes at one stroke the necessity for periodic appraisals to determine fair value. That value (the original cost) would be known at all times from the inventory records, which can easily be checked and verified. It would only be necessary to consider periodic changes in the rate structure itself.

There is, however, one aspect of this plan that remains open to criticism. For if owners of common stock are denied the special privilege of fat dividends (in times of rising prices), they are also deprived of an incentive to maintain and manage the property at a high level of efficiency. The obvious answer is that an incentive to good management should be provided. The incentive might well take the form of a sliding scale in the per cent rate of return on actual investment. There might be some difficulty in computing the degree of efficiency upon which the

incentive would be based, but the fact remains that each type of utility has some characteristic criteria of operating efficiency that could be made the basis for an agreed formula. If it be admitted that incentive wage systems are desirable in contracts between labor and management, it would seem to follow logically that an incentive plan would be equally desirable in contracts between the utilities and the public they serve.

Engineering Education in Latin America*

By S. S. STEINBERG

Dean, College of Engineering, University of Maryland

Editor's Note: **This paper by Dean Steinberg describes observations resulting from his mission as our Society's Ambassador of Good Will. The success of the mission may be best indicated by the following honors conferred on him in the countries named: Honorary Professor, Central University of Ecuador; Honorary Member, Cultural Institute of Ecuador; Special Permanent Representative, Federation of South American Associations of Engineering (headquarters in Uruguay) to the Engineering Societies of the United States; Honorary Member, Association of Engineers and Architects of Mexico and its Representative to the Engineering Associations in the Western Hemisphere; Honorary Member, Argentine Society of Engineers; and Honorary Member, Institute of Engineers of Chile.**

During the summer of 1945, at the request of the Department of State, the speaker traveled through the principal countries of Latin America and made a survey of engineering education. For some time previous, the Department had been receiving through its diplomatic and cultural officers many requests from the engineering schools in the other American Republics for information and assistance to enable them to develop their engineering courses, their faculties, and their equipment.

The purposes of the trip were accordingly outlined to be:

1. To make a general survey of engineering education in the other American Republics;
2. To meet the engineering educators and the members of the engineering profession in those countries;
3. To study bases for the exchange of engineering professors;
4. To arrange for a wider interchange of engineering and technical publications;
5. To advise on teaching methods, curricula, laboratory equipment, research, and related matters; and
6. To promote good will and establish closer relations between the educators and engineers of Latin America and those of the United States.

An itinerary was arranged which would permit visits to the principal universities and their engineering schools; to meet and to address the more important engineering societies; and to inspect a variety of engineering projects. The trip extended from July 15

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to November 1, a period of three and one-half months. Practically the entire tour was made by plane and totaled about 18,000 miles. As the War was still in progress during the early part of the tour, the Department of State arranged for its representatives in the several countries visited to take care of reservations and priorities, and in so far as possible eliminate some of the formalities of admission to and exit from the several countries visited.

The Department of State had hoped that the speaker would take a longer period for this survey, but due to certain commitments this was not feasible at that time. However, it was felt that this trip, which was the first survey of its kind in its coverage of engineering education and the engineering profession in Latin America, would serve as a reconnaissance and give a "bird's-eye" view of existing conditions.

Since in these republics the principal universities are generally located in the capital of the country, which is usually also the chief cultural and social center, it was planned to spend most of the time in the capital city and to make such trips to other centers as seemed desirable. The visit in each of the major cities extended variously from six to ten days. The speaker wishes to take this opportunity to express grateful acknowledgment to the representatives of the Department of State, both in this country and abroad, for the courtesy and help extended to him in all the countries he visited. Through the co-operation of the respective ambassadors and their staffs, and particularly our cultural attaches, he was able to accomplish much more in his comparatively short visits than would otherwise have been possible.

To anticipate a natural question, the speaker should state that many years ago, as a young civil engineer, he was engaged on railroad surveys and construction in Honduras and traveled widely in Guatemala, both located in Central America. There he was able to practice the Spanish he had previously studied and became closely acquainted with our southern neighbors. Living among them taught him to enjoy the Latin flavor, to appreciate its peculiar charm, and to admire the ability of the Latin Americans to get so much pleasure out of the art of living.

The speaker wishes to express his profound gratitude for the warm welcome and the many courtesies extended him by the educators and engineers, individually and collectively, in each of the countries he visited. Our colleagues recognized that the purpose of this mission was one of mutual helpfulness to the end that the engineering profession in the Americas might be better served.

The speaker expresses his sincere appreciation of the honor accorded him in being designated as the official representative of the Society for the Promotion of Engineering Education to the Latin American engineering schools. He is happy to inform the Society that its accomplishments were not unknown to many of the engineering deans and faculty members, and that copies of the JOURNAL of the Society were observed in several of the engineering libraries. The speaker had the honor to travel also as the official representative of both the American Society of Mechanical Engineers and the American Society of Civil Engineers to the Latin American engineering societies he visited.

ENGINEERING SCHOOLS VISITED

In all the twenty republics of Latin America there are about 60 profes-

sional engineering schools awarding degrees. Of these the speaker visited 25 schools located in 12 countries. The institutions visited include the more important ones, and are typical of the three chief classifications administratively, namely, national, state, and private; and they cover a wide range qualitatively.

Following is a list of the engineering schools visited, presented in the order in which they were inspected. The accompanying map of the tour locates them geographically.

Colombia
- National University of Colombia, Bogota.

Ecuador
- Central University of Ecuador, Quito.
- University of Guayaquil, Guayaquil.

Peru
- National School of Engineers, Lima.
- Catholic University of Peru, Lima.

Chile
- University of Chile, Santiago.
- Catholic University of Chile, Santiago.
- Federico Santa Maria Technical University, Valparaiso.
- Catholic University of Valparaiso, Valparaiso.

Argentina
- National University of Buenos Aires, Buenos Aires.
- National University of La Plata, La Plata.

Uruguay
- University of the Republic, Montevideo.

Brazil
- University of Sao Paulo, Sao Paulo.
- Mackenzie College, Sao Paulo.
- University of Brazil, Rio de Janeiro.
- Army Technical School, Rio de Janeiro.
- School of Engineering of Pernambuco, Recife.

Venezuela
- Central University of Venezuela, Caracas.
- Naval School of Venezuela, La Guaira.

Panama
- Interamerican University, Panama City.

Costa Rica
- University of Costa Rica, San Jose.

Mexico
- National Polytechnic Institute, Mexico City.
- National University of Mexico, Mexico City.
- University of Puebla, Puebla.

Cuba
- University of Havana, Havana.

General Observations

In general, Latin American engineering schools are patterned after those in Europe, particularly the French and the German. The present older generation of engineers and faculty members were trained either in their own schools, with advanced work in France, Germany, Italy, or Belgium, or secured their engineering education entirely in Europe. In the countries closest geographically to the United States, such as Mexico, Cuba, Costa Rica, and Panama, most of the more prominent engineers were trained in our engineering schools; while in South America, by far the largest number are graduates of European universities. The reasons in the latter case are the close affinity in lineage,

language, and customs; the fact that from many of the South American countries the distances and travel costs to Europe are considerably less than to the United States; and finally, we must admit that in past years we, as a nation, did not manifest too great an interest, culturally or academically, in the republics to the south of us.

With the progress of World War II, the Latin Americans began to marvel at our industrial and war production and to appreciate that we had the "know-how" so far as engineering was concerned. Our close co-operation in Western Hemisphere defense taught them to know us better than ever before. They came to a realization that

to compete, or even to exist, under the new economic conditions that would follow the War, it was necessary to develop fully their resources of manpower, of agriculture, of mines and minerals, and of industry.

Engineering and vocational education is unquestionably the basic need of these republics at the present time, and is the foundation on which all their future progress will depend. The national resources of most of the countries are practically unlimited and only as a result of education will they be enabled to achieve their maximum engineering and industrial development. To achieve this industrialization, they must now develop the necessary engineers, technicians, and artisans. National pride in each country actuates the desire to train their own engineers rather than depend upon foreign countries to do it for them. They have now come definitely to the conclusion that engineering education as exemplified in the United States is the pattern they wish to follow.

Educational Practices

In general, to enter an engineering school in Latin America, the student must be not less than 18 years of age, and must have passed satisfactorily six years of elementary schooling and six years of "colegio" (high school) from which he receives the degree of "Bachillerato" (Bachelor). In some engineering schools it is required that this degree be with distinction in mathematics and physics; in others, that a preparatory year be completed before entrance to the first year engineering courses; while in certain schools, a written entrance examination is required.

The engineering curricula vary in length in the different countries, but it usually requires five or six years for an engineering degree. In some institutions an additional year is required for completion of a thesis.

The offerings of engineering curricula are not so widespread in Latin American engineering schools as in our own. Some institutions still offer Civil Engineering only, but many have Chemical, Civil, Electrical, Mechanical, and Mining Engineering, separately or in combination; such as Civil and Mining Engineering, or Electrical and Mechanical Engineering. Many schools do not offer Mechanical Engineering because they lack the necessary laboratory equipment. Petroleum Engineering is being offered in some of the Andean countries. In many schools, Industrial Engineering is a popular course; a few offer Architectural Engineering, but the enrollment is small. Several institutions offer the certificate of Surveyor upon completion of a three-year curriculum.

As a result of the co-operative agreements entered into by most of the countries with the Institute of Inter-American Affairs, a great impetus has been given to health and sanitation. Consequently, greater attention is now being given in some of the engineering schools to the Sanitary branch of the Civil Engineering curriculum.

The airplane has been such a boon in the development of most of the Latin American countries that interest is now being manifested in a few institutions in developing courses in Aeronautics. For the first time since their colonization, it is now possible to travel by air with ease and comfort from country to country; and, what is even more important, several parts of the same country, formerly divided by almost insurmountable geographical barriers, are learning to know each other. To

cite one example: before the commercial use of the airplane it took one week to travel by slow steamer and railroad from Barranquilla, the chief seaport of Colombia, to Bogota, the capital, which is located at an altitude of 8,730 feet. The speaker's plane made this trip in less than three hours.

Since most universities are national, generally no tuition fees are charged. At some schools there is a small matriculation fee. One national university which does charge tuition, bases its fee on the income of the student or his family. A family with two children enrolled are allowed a 10 per cent reduction on the second fee; those with three children enrolled are allowed a 20 per cent reduction on the third fee. Since in these countries families are usually large, these reductions are important financially.

The curriculum in the engineering schools is usually rigidly prescribed and does not include any cultural subjects or elective courses since the university generally is regarded as a professional school. In some of the universities owned and supported by the National Governments, the law prescribes the curriculum in detail and changes must receive legislative approval.

The courses required in engineering do not differ very much from our own, but their treatment is largely theoretical rather than practical. The instructional procedures are highly formal. In most schools no textbooks are used. The professor prepares lectures which, at some institutions, are mimeographed and distributed to the students; in others, the students prepare notebooks for each course. Formerly the professors consulted French, German, or Italian books in the preparation of their lectures, but now books from the United States are preferred. As one dean expressed it, "Your textbooks are so clear and so practical."

The greatest deficiency noted in most of the engineering schools of Latin America is the meagerness of their instructional and laboratory equipment. This applies not only in the advanced engineering classes, but also in the basic courses such as physics, mechanics and sometimes in chemistry; usually, however, the speaker found the chemistry laboratories the best equipped. In many schools much miscellaneous equipment is seen, but it is old or antiquated. One dean frankly stated, "Our laboratory equipment is primitive"; while another called his equipment "museum pieces."

The most marked difference between our universities and those of the other American Republics is in the matter of faculty. The universities receive so little financial support that all or most of the faculty members are on a part-time basis; and this applies also to deans and to the rector (president) of the university. The teaching and administrative staffs carry on their university work in addition to their regular professional occupations. Consequently, there is usually no personal contact between student and instructor, and no time for research. A professor generally teaches one course which may require three to six hours a week of his time. At one institution, full professors are paid the equivalent of $45 to $50 a month; at another, the average rate is about $125 a month.

Most universities choose their faculty members by a system of competitive examinations. Faculty appointments are eagerly sought because of the honor they reflect, rather than because of the income. The appointment of a full professor is usually for life.

Rectors (presidents) of universities and deans are elected either by the administrative council of the university or by the faculty, for terms of two, three, or four years, depending upon the statutes of the institution. They may be re-elected.

Regular attendance by students at classes is generally not required since great weight is given to final examinations. In most institutions, a student is allowed up to 25 per cent absence from classes before a penalty is invoked. Because of the large number of holidays,—religious, national, and political,—and the part-time faculty, classes in some engineering schools actually cover only 75 to 80 per cent of the topics scheduled.

Due to reversal of the seasons south of the Equator, the academic year in most of the Latin American countries is different from ours, extending generally from March to November. In a few of the engineering schools visited, classes are held only in the early morning hours and during the late afternoon and evening. This permits the students to be employed gainfully during the day and allows faculty members to engage in engineering practice.

Campus life as we know it here does not exist in the Latin American universities. In very few institutions do they have dormitories. There are few university-sponsored activities and little emphasis on sports; but the students do have a great enthusiasm for politics, current affairs, and the administration of the university. Usually the university administrative council contains one or two elected representatives of the student body.

Upon completion of the engineering curriculum the degree usually awarded is that of "Ingeniero" (Engineer). While in some countries he may use the title of "doctor," which is their equivalent to our bachelor degree, he prefers to be called "engineer." This is because the professional engineer in the other American Republics has high social standing, and his income is usually higher than that of members of the other professions.

Most of the engineering libraries visited are stacked chiefly with French, German and Italian books and works of reference. However, at some schools the deans of engineering and faculty members pointed with pride to the increasing number of North American titles on their shelves and to the technical magazines and engineering society publications from the United States.

A custom in many countries which prevents students and faculty members from taking full advantage of existing library facilities, is that of keeping libraries open only during class hours. While some deans see no need for change, others stated they were anticipating budget increases to remedy this situation.

Engineering Societies Visitied

Since vocational schools are closely related to engineering schools and are an important factor in training technicians and artisans, the speaker was delighted to observe the interest being displayed by the more progressive Latin American secondary school educators in this type of training, so vital to industrial development. Through co-operation with the Inter-American Educational Foundation many of these schools have taken on new life, but their great need is for machinery and tools. In the course of his tour, the speaker had the pleasure of inspecting vocational and industrial schools in Peru, Chile, Brazil, Mexico and Cuba.

The speaker had the honor and pleasure of meeting the officers and addressing (in Spanish) the members of the 17 principal engineering societies in the countries he visited, and was the grateful recipient of their bountiful hospitality. He also had the opportunity of inspecting 12 cultural institutes, conducted co-operatively between our Department of State and the countries in which they are located. These institutions are doing an excellent job in promoting closer inter-American relations by lectures, classes in English, and general cultural activities.

Mention must also be made of the many engineering projects, both under construction and in operation, visited in the course of the tour. These gave the speaker an opportunity to meet the professional engineer on the job and to discuss with him problems dealing with labor, materials, transportation, as well as construction and operation methods. These inspection trips also afforded an opportunity to discuss local engineering education as viewed by the man in the field, in the factory, and in the drafting room.

Desire for Accrediting

The deans of the more progressive engineering schools are anxious for our Engineers' Council for Professional Development to inaugurate a program of accrediting of their curricula. They realize that while most of their schools may not be able immediately to meet our standards for accrediting, they are anxious for an inspection of their facilities and an evaluation which will apprize them of their needs to achieve recognition.

They look to us for advice and counsel, and want us to help them produce the capable professional engineers they will need to develop their great and practically untapped natural resources, for the betterment of their peoples and to aid in establishing a lasting peace. Whatever we can do to aid our colleagues in the other American Republics will be an excellent investment in advancing international good will and better mutual understanding.

Five Schools Described

Since time will not permit description of all the 25 engineering schools visited, five have been selected for brief treatment. Each school described is distinctively different from the others in the group.

National University of Colombia

This University, whose founding dates back to 1573, is the first in Latin America to carry out the plan of a "Ciudad Universitaria" (University City). This development brings together in one location all the units of a university which are usually widely scattered throughout a capital city. Such a plan makes possible a central administration, and where the area upon which it is built is large enough, provides for a campus and for social and athletic facilities. While several of the other Latin American countries are planning to erect a "Ciudad Universitaria" for their national universities, Colombia was the first to carry out such a project. It is located outside the central area of Bogota and was built about six years ago.

The buildings are of modern reinforced concrete construction, spacious in design and well lighted. Even though the elevation is 8,730 feet, there is no provision for heating to remove the chilliness of the damp air. Dormitories for students are provided on the campus.

Engineering laboratories are available for materials testing, for concrete, for soils and for asphalt. They are well equipped and can accommodate a student body of about 500. In addition to being used for instruction, the facilities of the materials testing laboratory are available for government testing and for the general public. Incidentally, A.S.T.M. standards are used in all laboratory work.

Courses in engineering have been in operation at this University since 1867. They are offered under the Faculty of Mathematics and Engineering. At Bogota, only one curriculum is offered, consisting of a six-year course leading to the degree of Civil Engineer, since the greatest need of Colombia is in transportation and construction. One of the requirements for the degree is the preparation of a thesis chosen from one of the following fields: Transportation Engineering, Hydraulics and Sanitary Engineering, or Building Construction.

The Faculty of Mines of the University is located in Medellin, where a five-year course is offered which leads to the degree of Civil and Mining Engineer. A special four-year course is also offered there leading to the degree of Petroleum Engineer.

The speaker found considerable research under way in the University at Bogota in the field of photoelasticity, in which this engineering school is equipped best of any of those visited in Latin America. As examples of their work, the stadium and other concrete structures erected on the campus were checked with the aid of photoelastic models.

The rector, the dean, and the professors give only part-time to their university duties. The dean is rotated every two years. Textbooks from the United States are used in most of the courses, and the faculty keeps in touch with our technical literature. A progressive spirit was noted throughout the inspection.

Federico Santa Maria Technical University

This technical university, located at Valparaiso, Chile, is unique among the engineering schools of Latin America. It was founded by Federico Santa Maria, a Chilean financier who died in 1925 and left an estate valued originally at $40,000,000, as endowment for this private institution to be established in his natal city. The founder had definite ideas as to the type of institution he wanted created, as evidenced by the following excerpt from his will:

". . . I drew up my first will in 1894, leaving a University to Valparaiso, but experience has shown me that this was a mistake and that it would be of much greater value to raise the level of the proletariat by means of a plan calculated to aid children, the primary schools, the trade schools, and finally, a college of engineering, thus putting within the reach of the most underprivileged but worthy student the highest degree of human knowledge. I consider it the duty of the wealthy to contribute to the intellectual advancement of the proletariat. . . ."

After a systematic study of the major engineering schools of Europe and the United States, the trustees adopted the German system of technical instruction. A beautiful site overlooking the Pacific Ocean was selected, and buildings erected which are modern in every respect and splendidly equipped. The first classes were opened in March, 1932.

A further provision of the founder's will was that a staff of foreign teachers be selected for the first 10 years. Accordingly, all the professors, and prac-

tically all the equipment, are German. The laboratories are spacious and well equipped. Many of the faculty members are employed on a full-time basis.

To carry out the intent of the founder, the University admits to its departments three categories of students:

1. Students between the ages of 13 and 16 who have completed the sixth year of primary school or three years of junior high school. These students enter the School of Apprentices and proceed as follows: (*a*) After four years (two and one-half in the School of Apprentices, one-half in industry, and one in the Elementary Technical School) are awarded the certificate of Master in one of the following specialities: mechanics, foundry electricity, building construction, or carpentry; (*b*) Capable students may continue their studies in the higher courses until they receive the certificate of Foreman, or may enter the College of Engineering to pursue the three-year course leading to the degree of Mechanical Engineer, Electrical Engineer, or Chemical Engineer, the only degrees granted by the University.

2. Students between the ages of 15 19 who complete the secondary school enter the Preparatory School and proceed as follows: (*a*) After four years (one and one-half in the Preparatory School, one-half in industry, one in the Upper School, and one in the Technical Institute) are awarded the certificate of Foreman in one of the following specialities: mechanics, electricity, chemistry, or building construction; (*b*) After six years (one and one-half in the Preparatory School, one-half in industry, one in the Upper School, and three in the College of Engineering) are awarded a degree in engineering.

3. Industrial workers between the ages of 16 and 40 may enter the Night School. Here instruction is given in mechanics, blacksmithing, tinsmithing, electricity, carpentry, and upholstering. At the end of two years, students may take a one-year industrial preparatory course which admits them to the Elementary Technical School. Capable students may then continue in the courses prescribed for entrance to the College of Engineering. Those who do not intend to pursue advanced studies may take special courses for one year leading to the certificate of Skilled Workman.

The majority of the students in the University do not pay fees. Students without financial means receive free, in addition to instruction, room, board, laundry, study materials, work clothes, and medical attention. Students from wealthy families are required to pay fees. Since dormitory facilities are limited, first choice is given students with outstanding academic records.

At the time of the speaker's visit, approximately 70 students were enrolled in the College of Engineering. The last graduating class consisted of 15, equally divided between Mechanical, Electrical, and Chemical Engineering. It was explained that the training of Civil Engineers is left to the other universities in Chile.

National University of La Plata

This University, located in the city of the same name, is one of the six national universities in Argentina and is the second largest in the country. Originally opened in 1897 as a provincial university, it was nationalized and its scope greatly enlarged by statute in 1905. The method of university ad-

ministration in the United States was used largely as a model. The head of the University is known by the title of "Presidente" (President), and not by the usual title of Rector. This University is unique in that it comprises a complete educational system planned as a unit from the primary school through the University. It is housed in old buildings, but the spirit is new and progressive.

An entire building of good size is occupied by the Institute of Physics, one of the outstanding departments of its kind, not only in Argentina, but in all Latin America. Its laboratories are well supplied for both instruction and research and contain the most modern equipment. The recently organized Institute of Aeronautics is housed in a temporary frame building with a new wind tunnel of elaborate design available for instruction and research.

The instruction in engineering is under the Faculty of Physico-Mathematical Sciences. There is a curriculum offered in Mechanical and Electrical Engineering leading to the degree of Engineer after five years of study; also one in Hydraulic Engineering, of six years' duration, which leads to the same degree. Candidates for the degree of Civil Engineer must enroll for the course in Mechanical and Electrical Engineering, adding certain subjects during the several years, as well as taking an additional year of specified courses in Civil Engineering. There is also a course in Land Surveying which after three years of study leads to the diploma of Surveyor.

The engineering laboratories are quite well equipped, with an especially good materials testing laboratory, which, in addition to its availability for instruction, does testing for the government and conducts research in concrete.

There are 3,000 students under the Faculty of Physico-Mathematical Sciences which includes those in Engineering, in Mathematics and in Physics. The faculty consists of about 60 professors and 25 assistant professors, on a part-time basis, and 40 assistants, with much of the teaching responsibility falling on the assistants. No textbooks are used, but lectures prepared by the professors are mimeographed for sale to the students.

University of Sao Paulo

The Polytechnic School of the University of Sao Paulo was founded in 1894. It is located in the city of the same name, the center of the most important industrial area in Brazil. It offers curricula in Civil Engineering, Electrical and Mechanical Engineering, Chemical Engineering, and Mining and Metallurgical Engineering. The first three require five years to complete; the last takes six years. Due to the scarcity of engineers in Brazil, narrow porfessional specialization is prohibited by law, as the objective is to produce men who have a broad general training and who will be competent in more than one field of engineering.

The Polytechnic School has approximately 500 engineering students. About 40 to 50 are graduated each year. The facilities and equipment are adequate; but the close affiliation of the school with the Institute of Technological Research of Sao Paulo gives it an advantage in instruction, in access to equipment, and in contact with industry and its problems, possessed by no other engineering school in Latin America.

The Institute, which is located adjacent to the Polytechnic School, is

housed in a building specially designed for its operations. It is supported by funds from industry and from the State of Sao Paulo. Its annual budget is about $300,000 (U.S.), one-third coming from the State treasury and two-thirds from an organization representing the industries of the State. The Institute conducts tests and research for government and for industry in all fields of technology. Its laboratories are excellently equipped and well staffed. The staff consists of a director and 60 engineers and technicians all on a full-time basis. The Institute issues, on the average, 600 test reports and 10 research reports monthly. Its Administrative Board consists of eight members: four professors from the Polytechnic School, two representatives from industry and two representing the engineering profession.

This Institute is the outstanding cooperative research organization in Latin America and is serving as a model for similar organizations already inaugurated or planned in some of the other republics.

Central University of Venezuela

By a decree of the National government, issued in October, 1944, the instruction in engineering at this University, which was founded in 1725, was re-oriented and patterned on the methods employed in the United States. A School of Engineering was organized consisting of four departments: Civil and Sanitary Engineering; Architecture; Geology, Mines and Petroleum; and Industrial and Mechanical Engineering.

Provision is made for a faculty to be employed either on a full-time basis, on half-time, or on part-time. The dean is elected for a three-year term by the faculty and student representatives. He may be re-elected. A director is elected for each department by vote of the faculty of that department.

At the time of inspection of this University by the speaker, the teaching staff consisted of 14 full-time faculty members, including the dean and his advisor. The latter had come from the United States as an exchange professor to help with the reorganization of the School. This departure from the customary part-time faculty is made possible by the favorable financial situation in which the government of Venezuela finds itself as a result of the income from its petroleum resources.

The official decree, signed by the President of the Republic, sets forth in much detail the manner of administration of the School; the duties of the dean, the faculty and the students; the requirements and procedures for the admission of students; the courses of study in the several departments, and their sequence; the method of administering tests and examinations; the grading system; and the discipline of students and penalties.

The School of Engineering is temporarily housed in a large building on the site purchased for a new "Ciudad Universitaria" (University City) now under construction. This is located on the outskirts of Caracas and will afford a spacious campus. Units are planned for erection in the near future for the School of Engineering. At the time of the speaker's visit, the temporary quarters had just been occupied and the classrooms and laboratories were being fitted up, with much of the equipment still in cases and crates. The dean and two of his faculty had just returned from the United States where they made a study of several engineer-

ing schools and purchased laboratory equipment.

The total student body in engineering is approximately 400, with one-half of them in the freshman class. Textbooks are required in the various courses and most of them are from the United States. All engineering curricula are four years in length and degrees are awarded in the several fields taught.

The spirit displayed in this School of Engineering was the most progressive of any observed in the countries visited. If the plans now proposed for this institution are carried to fruition, it should become the outstanding engineering school in Latin America.

The Place of Agricultural Engineering in Agriculture

By ERNEST L. ANTHONY
Dean of Agriculture, Michigan State College

Because you who constitute this meeting today are for the most part students and specialists of the various fields of agricultural engineering, in fact some of you have not only developed and expanded this area of our educational machine but have conceived this important branch of engineering science, it is perhaps very audacious for me a rank layman to even attempt to offer any observations to you. I want to assure you, however, that even as a layman my interest and friendship to this field of agricultural education and service are both sincere, constant, and of long standing. I speak, therefore, in the kindly interest of an even better and more broadly conceived and developed agricultural engineering and its place in our future modern agriculture. Speaking as an administrator in agriculture rather than as an engineer I hope I may serve a purpose on this program.

The discussion today with reference to accreditation, and the industrial requirements in the field of agricultural engineering I think reflect the efforts of the profession and its leaders in this field to rise above the earlier criticisms of the more highly developed fields of engineering such as electrical, mechanical, and civil that, agricultural engineering was a practical art rather than a science, and its workers were gadgeteers rather than scientists. This effort to be fully recognized as an equal segment of the entire engineering field I am sure is wholly desirable and should have the most complete support of the entire field as well as its friends and supporters.

I am interested in the field of agricultural engineering as a servant of agriculture and not as a step-child of engineering. I shall confine my remarks to this position. Modern agriculture today is a business. The farmer of tomorrow, who survives and continues to be a dominating influence in agriculture rather than just a subsistent peasant, will be the man who will have brought to his farm the best application of business methods coupled with efficient and modern management practices.

This calls for a careful consideration and recognition of the economic factors of costs of production, depreciation, capital costs, labor use and costs, and the most efficient fit of the several different farm enterprises.

Agriculture so far has been serviced by the agricultural economist and farm management specialist, and no criticism may be attached to their services or efforts. The problem, however, is one of modern engineering. Agriculture is crying loudly for this broadened concept of the place and function of the agricultural engineer.

I recall reading a definition for engineering in which this field was defined as "that function which combined direction and organization of men, with the application of the natural forces, to the best utilization of the materials of nature." Certainly modern agriculture today is concerned with these same basic fundamentals. Its future prosperity if not its very future existence depends upon the best possible organization of its decreasing total manpower, around its natural resources, and by the most efficient use of its basic biological and physical forces of nature. I do not think that it is too much to expect that the field of agricultural engineering might well take the lead in dictating management practices based on the best engineering principles which should govern the modern farm operation. This seems to me to be one of the most logical and natural expansions for the agricultural engineer.

It may mean a broader concept and training in the fields of Economics, possibly some better understanding of social principles, and certainly a broader appreciation of the principle of economic efficiency of mechanization as a part of farm management in addition to the present all absorbing concept of the technical perfection of the farm machine.

Time will not permit me to go into a detailed discussion of the many expanding fields of service to agriculture which are demanding more and more well trained men in the fields of agricultural engineering. They are many; they are important; and they are ever expanding. Where in the early days of the development of agricultural engineering, most men like our great early leaders in this field, such as Dr. J. B. Davidson of Iowa, were called upon to give their time and genius to the improvement and perfection of machinery and equipment which would lighten the daily toil and lift the burdens from the backs of our toil worn farmers, today this is but only a segment of much greater activity.

There is today the need of scores of well trained men who know much about the problems of soils and soil conservation. There is need for many trained men in the rapidly expanding field of food technology and food processing. Likewise, the whole new field of food preservation, dehydration and freezing is almost completely without well trained personnel. These all are jobs more logical for the man trained in the field of agricultural engineering than in any other branch of the science of engineering.

Also, one must not overlook the problems of better methods of transportation for agricultural products, nor the great field of yearly losses of many millions of dollars in agricultural income through frosts, droughts, floods, insects, and disease that await solution or control by the application of engineering principles and practices.

Then, too, with the mechanization of agriculture there is developing a great dearth of well trained servicemen and salesmen who not only are familiar with farming and the limits of farm practice, but also have competent training in the fields of engineering that they may bring satisfaction to both the farmer and the manufacturer or dealer in the handling, distribution, and servicing of this vast array of new and complicated machinery.

In closing may I say that I think agricultural engineering like all other fields of modern agriculture is in for a great period of growth and change. There is

great danger as I see it in attempting at this time to "freeze" it to some fixed pattern or idea.

The thinking in agricultural engineering must continue to be equally flexible and adjustable if it is to keep apace with the demands still to be made upon it by the new agriculture of tomorrow.

Agricultural engineering must cease to be something apart by itself and become one of the very foundation stones on which the agriculture of the future must rest.

The Use of the Graduate Record Examination in the Selection of Graduate Engineering Students*

By GEORGE S. SPEER

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The presentation of a paper such as this is an admission that our present methods of selection of students for graduate training are not all that might be desired; there are lacks, defects, and inadequacies in the techniques now employed. Obviously, this paper must also assume that there is a general concern over our present failures, and a genuine desire to improve the selection process. We must also assume that we are willing to add to our present methods whatever seems to promise to improve our selection, and are equally willing to discard any device now employed which appears to be inefficient or unnecessarily cumbersome.

In the examination of our problem it is desirable to look first to the purposes for which selection is desired, and to the present methods of achieving these purposes. Unless we are prepared to admit that we are totally inadequate in our present practices, we should, before adopting a new technique, review what we are already doing, and consider how well our present methods are achieving the goals we desire. This review may suggest to us that there are some present practices which may be retained, others that may be useful if improved, and possibly some that must be discarded. We will then be in a better position to decide whether a new device appears sufficiently promising to be employed.

Let us briefly examine these three questions in turn: What are we trying to select? How are we doing our selection now? Will the use of the G.R.E. contribute materially to an improvement in our present technique?

There is probably no universally accepted description of a desirable graduate student. Most of us, however, probably will agree, though this is an oversimplification, that the desirable graduate student is one capable of using skill and judgment in the application of his factual knowledge in developing new and useful techniques for the solution of real problems, whether new or old.

Candidates for graduate degrees are selected today through three methods, either singly or in combination: the undergraduate degree, undergraduate grades, and comprehensive examinations. Of these three, the degree is the least specific, and the least reliable, measure of ability. Whatever defects may be shown in the granting of grades or the use of examinations, are cumulative in the undergraduate degree, which almost universally represents merely the accumulation of grades or examination scores. It is not entirely without

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merit, however, for not everyone is able to accumulate these course credits. Although economic factors do prevent many with ability from attending college, and permit the attendance of some who lack ability, the college graduate is, on the whole, of superior mentality and knowledge.

Grade averages are only little more specific than the degree, but the individual grades (the transcript of grades) are of considerably more use. So much has been said in criticism of grades, that it appears wise to consider in more detail the contribution which is made to our problem by college grades, particularly since grades are still, in spite of the critics, the most widely accepted method of evaluating educational progress.

Grades, in the undergraduate program, are determined by three factors, only two of which are usually admitted publicly. What they are supposed to represent is, of course, the factual knowledge possessed by the student, though they may represent merely the student's ability to outguess the professor, and so study only for the questions which appear on the examinations. A second factor, usually acknowledged, consists of those personal qualities of promptness, thoroughness, neatness (as the use of a typewriter), accuracy, initiative, and dogged industry. Almost anyone will recognize that the student who hands in, on time, a neat, legible, completely accurate paper, showing the results of hard work, and efforts which have gone beyond the requirements of the assignment, deserves a better grade than another student who may know as much, but is disorganized and untidy in his thinking.

There is a third factor, neglected in the literature, and rarely admitted publicly, but of great weight in the determination of the grade. This is the ability of the student to impress and influence his professors, to affect them as a person. This trait is in some respects more important than either of the other two, for it illustrates, more nearly than anything else, the total integration of the person in action, rather than as a static expression on paper.

Consider three graduate students: A, who is an extremely introverted but brilliant student; B, who knows a great deal, is promising in research possibilities, and is so personally maladjusted that he cannot get along with anyone in the department; and C, who is less brilliant than A, knows less than B, but is a good student, energetic, and knows how to secure the maximum cooperation of everyone with whom he comes in contact. He is perhaps editor of the student paper, president of the fraternity council, or chairman of the Junior Prom. We predict that ten years from now C will own the factory that employs A and has discharged B.

Regardless of how they are determined, grades are an expression of achievement and performance in a specified situation. Although it is admitted that grades are subject to many errors and variations, and that grades are not equivalent from one school to another (or even from one department to another, or one instructor to another), high school grades have frequently been shown to be the best single predictors of college success in liberal arts colleges. Overlooking for the moment inequalities and injustices, we must recognize that grades are not distributed at the capricious whim of an instructor with unpredictable standards. We may disagree with, or disapprove of, his standards, but we must also accept his grades as his best expression of a total performance by the

student in relation to those standards. Except in rare instances, the performance of the student results from his complex of habit patterns, and may thus be expected to continue in approximately the same way. That they do, is shown by their value in predicting the student's future adjustment.

The same arguments, and the same conclusions, may be applied to the use of college grades in the prediction of graduate success.

Almost any college grading system eliminates the obviously unfit, those who are certainly unsuited to collegiate education. A further screening occurs in the selection of students for graduate work through the use of grade averages, tending to eliminate the weaker students. Thus the extremely poor students tend to be elminated through failing grades, and the mediocre students obtain such grades as to discourage any planning for studies at the graduate level. The others, then, receive such grades as to warrant consideration for graduate work.

However, colleges differ in the relative ability of the students admitted as freshmen, in the standards of grading, and in the relative abilities of their graduates. Thus it is possible that students who are eliminated in one school might well have been able to graduate from another. A grade of "C" in one course may represent a degree of performance which would have received an "A" in another department, and failure in a third.

Some of this difficulty might be overcome if the various colleges and universities could frankly and objectively examine the student bodies attracted to each, their policies with regard to grades and graduation, and then openly state the level of ability which each will accept, train, and graduate. This, particularly for those schools which commonly attract students of relatively limited abilities, is not expected to occur in the near future.

It has, therefore, been necessary for the graduate schools themselves to analyze the products of the undergraduate institutions from which they draw their students, and in some way evaluate grades so that they may establish for themselves a stable point of reference by which to appraise the individual student.

Such a task is relatively easy when the graduate school draws its student body from a small number of undergraduate schools, but becomes much more difficult when the problem is the appraisal of a few students from each of a large number of schools which may differ greatly in the quality of their products. In these cases, the graduate institution must depend on something other than grades to measure the suitability of the prospective student. Such an instrument must yield significant information, must be fair to students from any school, and should have the same degree of accuracy from year to year. The obvious answer to this problem has been the use of objective, usually nationally standardized, examinations.

An additional complication is found for those institutions which attract as graduate students, individuals who have spent an interval of some years in industrial employment following their graduation. When a group of such individuals represents a scattering of undergraduate institutions, it is extremely difficult to evaluate their potential abilities. In so far as grades represent information they are, in these situations, virtually worthless, for employment and lapse of time have increased skills and judgment in some areas, and allowed

other areas of information to virtually disappear.

The use of achievement tests alone, in such circumstances, will be unfair to the capable student who has, since graduation, been employed in a situation which has encouraged development in rather narrow directions. Forgetting, as we know, is a constant process, and such a student is at a disadvantage when compared with a recent graduate of perhaps considerably less aptitude. Or, if he is one whose education has been interrupted by military service, an achievement test alone is inadequate, as it measures only what he knows, and gives no indication of the rate at which he can acquire new facts or reacquire old ones. For this reason the selection of graduate students should include an appraisal of general mental aptitude. Whether tests of aptitude for chemistry, physics, and mathematics should also be included is less certain, though they would frequently appear to be desirable.

One example will illustrate the problem, and the advantages of the use of aptitude tests in connection with measures of achievement. Four years ago a group of twenty students applying for graduate work in one department at Illinois Institute of Technology were given a battery of admission tests, including tests of preparation in mathematics, aptitude for mathematics, and general mental ability. On the achievement test, Student A received a score at the 85 percentile; Student B at the 86 percentile. The difference is unimportant. On the mathematics aptitude test, Student A scored at the 68 percentile, Student B at the 98 percentile, a considerable difference. On the mental aptitude test, Student A was at the 7 percentile, and Student B at the 99 percentile. Obviously, although they are equally prepared in mathematics, one student is potentially a superior individual.

The decision to use examinations raises two questions: "What should be measured?" and "How accurately shall it be measured?" The reliability of the test, that is, its agreement with itself, is a technical problem for the testmaker, and we shall only insist that this be as high as it is mechanically possible to make it. The validity of the examination, that is, its agreement with subsequent success, is a more difficult problem. As we have seen, grades have largely eliminated the inferior and mediocre students. As a whole, college graduates are superior in intelligence. Because of different standards in the colleges, there is still a large spread of abilities and information, but the graduates are much more homogeneous than the freshmen. Where the graduate institution establishes fairly high standards of grade averages, and tends to recruit its student body from a limited number of undergraduate schools, the homogeneity of its graduate student body will be greatly increased. This homogeneity tends to depress the validity coefficient, for by the very nature of the correlation technique, the coefficient expressing the relation between two variables is reduced where the populations are homogeneous, and increased where they are heterogeneous.

It is desirable that such an examination have more than one form, equally difficult, so that the examination may be repeated if it is desired to measure improvement over a period of time, in cases where the student apparently justifiably feels that he was not able to do himself justice, and for all the many other legitimate occasions for repeating an examination. For purposes of selecting graduate students,

such an examination should be considerably more difficult than one intended for freshmen, or should be standardized with a graduate population.

And what is to be measured? The type of instrument or process used in selection will definitely affect the undergraduate institution in the emphasis which it will place on its various aspects of the training program. Although the use of an objective examination may be intended merely to establish a common measure for prospective students, it will, in part at least, dictate the undergraduate educational experience. For this reason it is important that the examination include only material which is pertinent to the problem: the prediction of success in graduate engineering studies.

With these considerations in mind, we may examine the G.R.E. and its possibilities.

The G.R.E. is a comprehensive examination in eight general fields: Mathematics, physics, chemistry, biology, social studies, literature, fine arts, and a general vocabulary test (verbal factor). The scores reported express the ability of the student "to answer questions, solve problems, and exercise judgment based on knowledge of the material." There are, in addition, 90-minute advanced tests in a number of fields, including chemistry, mathematics, physics and engineering. The examination requires two half-day sessions, for a total of eight hours, though the actual working time is only approximately six hours. As is obvious, less than half of the examination applies specifically to engineering or related subjects. There is only one form of the examination.

The examination is objective, permitting a much broader sampling of information and ability than would be obtained otherwise, and an increased reliability and validity.

The question of whether the same test should measure both knowledge and ability has not been definitely answered by test experts. The G.R.E. includes both factual and judgmental items, thus expressing in one score an indefinite combination of what the student knows and how well he is able to make judgments with what he knows.

The examination does not include any measure of general aptitude, although there is included a measure of verbal aptitude.

In our opinion, a more serious defect in this examination, for engineering schools, is the emphasis on non-engineering subject matter. Although it may be of interest to know that a student has acquired a nice appreciation for literature or the fine arts, this information is non-essential in predicting his success as a graduate engineer. The time might much better be used in measuring significant traits or abilities.

In defense of the emphasis on social studies, it may be said that there is a general feeling that the engineer needs a broader social viewpoint. This is undoubtedly true, but the classic studies of Hartshorne and May long ago demonstrated that knowledge of social values was not necessarily associated with social behavior. There is also the question of whether engineering schools should teach a social viewpoint, particularly at the graduate level, or should select for engineering-training students who already have the desired attitudes and values.

We already have a technique for determining the kinds of personalities possessed by applicants. Grades to a

large extent reflect the impression created by a total personality in operation. As these traits are important, they should be evaluated and recognized in some fashion which will be generally meaningful, without distorting the statement of intellectual ability and educational achievement usually understood by grades. This can be accomplished by using scores on standardized examinations in the undergraduate school in place of the grades now used, and adding some type of measure which will indicate the dynamic structure of the individual personality.

The limited testing of engineering subjects, and the amount of time devoted to other subjects, make this examination of doubtful value in the selection of graduate engineering students. It seems wise to search for some other test for this purpose.

We conclude then, that in the selection of students for graduate work it would appear that they should be measured or evaluated in four distinctive areas. (1) Personal characteristics should be emphasized, measured and evaluated to obtain a picture of the dynamic structure of the individual personality, (2) the amount of factual knowledge should be measured objectively in order to determine that the student possesses at least a minimum background for the future pursuit of his education and training, (3) a measure of at least general mental aptitude, and possibly aptitude in specific fields, and (4) his actual achievement in an academic situation as an undergraduate student should be included in order to give an estimate of the ability of the student to work in a classroom or laboratory setting. In the measurement of knowledge, and probably in the analysis of grades, we should include only those areas of knowledge which are applicable or relevant to the studies to be pursued at the graduate level. The G.R.E. does not seem to be adapted to these considerations.

Practical Economics for Engineers*

By CHARLES E. YOUNG

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The field of engineering education is, as you probably know, one in which my company is deeply interested; its interest finds tangible expression in the activities of the Westinghouse Educational Foundation, the annual Science Talent Search, the George Westinghouse Memorial Scholarships and a host of other activities in the colleges and secondary schools of the country.

It is a particular privilege to be allowed to have the first word—though certainly not the last—on the teaching of practical economics to engineers. I have sometimes suspected that men talk most freely on the subjects they know least about, and you must forgive me if in the course of this discussion I sometimes err in that direction. I have never been subjected to the rigors of an engineering education, and I have never taught economics to engineering students. My apology for being here at all is that I have lived and worked with engineers for the past several years trying to find out what economic knowledge they needed to operate their business and trying to help them obtain the necessary facts and make the necessary guesses. They have tolerated me as a rather dull fellow (if I were not, I would be an engineer myself) and as time has gone on we have gradually become a little more intelligible to each other.

I am going to attempt three things this afternoon: first, to explore the proper objectives of an economics course for engineers and some of the reasons why the ordinary introductory course in college economics does not meet these objectives; second, to indicate what a satisfactory course should include; and third, to illustrate some of our own thinking about practical economics with examples of some of the things we have done in recent years.

Let us turn first to the objectives to be sought in an economics course for engineering students. Such a course should aim, I believe, to engender a degree of economic literacy and understanding of current economic developments and discussions that will permit the engineer to sift the wheat from the chaff and to reason intelligently toward sound conclusions—in short, to read and listen with discrimination, and to perceive his own best contribution to the general welfare.

In his excellent book, "The Road to Serfdom," Frederick Hayek points out the special proclivity of specialists and technicians to turn to authoritarian governments for the achievement of their particular objectives and programs without understanding the heavy price involved in the basic threat to their freedom and happiness which the whole structure of authoritarian government presents. Particularly to a mind schooled to abhor uncontrolled

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variables, the lure of a wholly-controlled economic system may be very strong. It would be tragic indeed if our centers of scientific training, to which we look for so much of our future progress, were to become a breeding-ground for the eradication of the last great stronghold of human liberty.

It has been my own experience that many engineers of my acquaintance have been particularly prone to seek automatic solutions of economic problems, to try to derive magic formulae to reduce the extremely complex variables of economic and social behavior to manageable parameters, and to believe that if only sufficient authority were granted to enforce a so-called "scientific" approach to economic and social problems, all our ills would be cured. It is not customary for proponents of this view to describe their proposals as a "Reign of Terror," but the history of all authoritarian governments teaches us that that is where these proposals lead.

We come, then, to a second stipulation—that the economics to be taught in engineering colleges should be consistent with both the limitations and the overpowering virtues of a free nation and a system of private economic initiative.

The intellectual maturity in economic matters which is to be sought in the economic instruction of engineers brings us to a third objective—an appreciation of the inter-relationships of economic, social and political forces which mold and alter the course of economic events. These pressures exist and operate in any form of society, whether authoritarian or free, albeit in somewhat different forms. Transfer of authority to a central government will not put iron and copper into the soil of a nation, nor will it produce machinery and technology where none exists. It is essential that engineers (as well as other groups) understand the foundations on which a prosperous economy rests, and the relationships between the various parts of the economic structure built on these foundations. That engineers are not wholly lacking in such basic understanding is illustrated by the frequency with which outstanding engineers have been called upon to make economic surveys of areas to be developed. This understanding of economic foundations and relationships should, in fact, be especially amenable to those with engineering training, with its emphasis on objective analysis.

Apart from these general observations, consideration of the curricula and interests of engineering students develops three further assumptions bearing on economics courses for their instruction. First, it is apparent that the students cannot devote any large number of course hours to the study of economics. The majority of students probably would be limited, at the outside, to one two-semester course meeting three hours per week Those desiring additional electives in such fields as money and banking, corporation finance, and statistics ought to be allowed to work them in without regard to prior completion of the basic course I shall later describe.

Second, it can reasonably be assumed that engineering students do not propose to specialize in economics or pursue, during their college course, any specialized branch of economic study.

Third, it should be reasonable to assume that engineering students have sufficient background in mathematics to absorb quantitative relationships not ordinarily taught in introductory courses in economics.

With this background, we can now examine a typical course in the principles of economics. It is usually taught predominantly to sophomores, for the reason that it is the keystone of the whole Economic Department curriculum, providing the basis for later more specialized study by economics majors. At least in the larger schools it tends to be a mass-production, assembly-line affair, with massive assemblies for lectures and a minimum of opportunity for detailed discussion of difficult points. The application of principles to workaday affairs is usually touched on, if at all, only lightly; the term, "applied economics," is a stigma to which relatively few professional minds are willing to expose themselves, for it connotes a popularization and vulgarization of pure principles which they have labored long and diligently to discover and develop, and over which they dispute among themselves long and loudly. The principles themselves tend in many cases to rest upon the shaky foundation of assumptions far too rigorous for application to the everyday world—for example, perfect atomistic competition, perfect mobility of the factors of production, and, in the so-called "modern" school of thought, a perfectly elastic response to minute variations in the interest rate or to massive outpourings of newly-created funds, and a charmingly unsuspicious attitude on the part of businessmen and investors toward their political overlords and the manipulators of their money.

Let me make it clear at once that I am not advocating the abandonment of fundamental principles in the teaching of economics; rather, I am arguing, in this special instance, of an economics course designed primarily for engineers, for the teaching of principles in an illustrative context which will clarify their application to everyday affairs and make them intelligible to students who will devote their lives to being economic laymen instead of professional economists. There is no reason why such fundamental concepts as marginal utility, marginal cost, diminishing return, or the propensities to spend, consume, save and invest must be surrounded by an ethereal vapor.

The typical beginning course in economics which I have rather summarily described falls down on two major counts in meeting the requirements of a course for engineers. First, it is generally too abstract to serve as a basis for understanding day-to-day and year-to-year economic developments, and in any case it leaves to the student the task of transition from the assumed perfection of the world of theory to the disagreeable imperfections of the world of reality. Second, it is generally taught at the wrong period of the college career for engineering students, running as a second-rate competitor to the fundamental courses in the physical sciences and engineering which are his chief interest, and easily forgotten long before it can be applied in his post-collegiate career.

It is desirable for several reasons that an economics course for engineers of the general type I am going to describe should come relatively late in the engineer's training, and preferably in the final year:

(1) The pattern of objective analytical thought should be firmly set by the time the course is offered.

(2) The general mental maturity and capacity of the student will

be greater toward the end of his college course.

(3) Approaching emergence from the somewhat secluded atmosphere of the college campus into the business world should heighten the interest of the student in how that world operates.

(4) The course is not intended as a prerequisite for advanced study, as would be the case in the economics department.

A satisfactory course in practical economics for engineers should stress the production and distribution of income and wealth, with emphasis on the distinction between *real* income and wealth and *monetary* income and wealth. A very satisfactory course could be woven about the theme of national income, showing how the production of that income is divided as between capital formation of various kinds, production of consumers' durable and non-durable goods, privately-rendered services and government activities, and how the distribution of that income is divided as between salaries and wages, agricultural income, income of non-agricultural proprietors, interest and rents, corporate dividends and corporate savings. This background provides the setting within which economic events occur and provides a picture of relative magnitudes which are very frequently misunderstood. In the study of the various segments of national income the applicable economic principles governing their behavior can be brought out and developed in a context which is readily recognizable to the student. At least a rudimentary explanation of the operations of money and banking should be included, and at least a good synopsis of the means and procedures by which goods move from their raw material state to their ultimate consumption. The problems of business fluctuations, various proposals for their stabilization, and the disadvantages inherent in the various proposals should be presented.

You will note a strong emphasis here on the mechanics of economic behavior. It is, of course, very difficult in these times to get an economic presentation which is not flavored strongly with philosophy and ethics, but it is my own belief that an understanding of the structure and operation of economic machinery should precede and temper the philosophical and ethical connotations which will, in any case, be supplied by the individual student.

Undoubtedly the most difficult part of the course from the standpoint of instruction, but at the same time one of great value to the student, would be the tracing of the manifold, and often complex, inter-actions among the various segments of the economy. Yet it is exactly here that the understanding of the general public, and even of professional economists, has fallen down most severely and disastrously. Relationships between the incomes of various economic groups, such as labor, agriculture, white-collar workers and investors, have been widely ignored. Relationships between costs and prices, between wage rates and efficiency, between money supply, monetary demand, available capacity and prices have been rudely overlooked under political and social pressures. It is this sort of understanding of the basic components of the economic machine and of their inter-actions which a practical course in economics should lay before the engineering student. We are all hoping for great scientific strides from current and future classes of engineering students as they take up their respec-

tive parts in our economic life, and they should begin that life with an adequate understanding of where they fit into it, what the nature of their contribution is to be, and the pressures that are at work to nullify that contribution.

Let me cite two examples from our own Westinghouse attempts to piece together various pieces of the economic picture into intelligible and useful information. I will touch first on the inflation prospect and second on the question of productivity.

About two years ago our management asked for a report on the prospect of postwar inflation. The experience after the last war, of course, predisposed many people to expect a repetition, but others were speaking up vociferously about the prospect of drastic deflation when the war ended, with huge numbers of unemployed workers and great excesses of productive capacity in many lines.

Fundamentally, the questions we sought to answer were how much money businesses and individuals might be willing to spend in postwar years, how much capacity would be available to meet that demand in terms of prewar prices, the price change indicated by any unbalance between these demand and supply figures, and, as a check, the price changes indicated by changes in cost since prewar.

Our first step was to examine what had happened to the amount of money in the country during the war. What we found was that bank deposits and currency had more than doubled between the middle of 1940 and the middle of 1944, with every prospect of still further increase, for the rise was closely tied to the expansion of government debt. The prospect that businesses and individuals would have more than twice their prewar amount of liquid funds, without regard for the substantial increase in their holdings of bonds and other assets, led us to expect, in general, a smaller regard for money as compared to goods, and an aggressive attitude on the part of business concerns in using their added funds for expansion.

To get a more precise picture we turned to the figures on gross national product, which represents the money value of all goods and services produced in the country each year. In comparing these figures with the money supply of the country over a forty-year record, we found a fairly consistent relationship, which can be described as the "turnover" of money in the production of goods and services. Having an estimate of how much money there would be, and making various estimates of how rapid the turnover of that money would be, we were able to make a range of estimates of gross national product from the standpoint of probable willingness to spend dollars. What stood out at once was that our most conservative estimates of turnover, allowing for declines below all previous levels, still indicated a very large dollar figure for this willingness to spend. This result stemmed, of course, from the magnitude of the money supply itself.

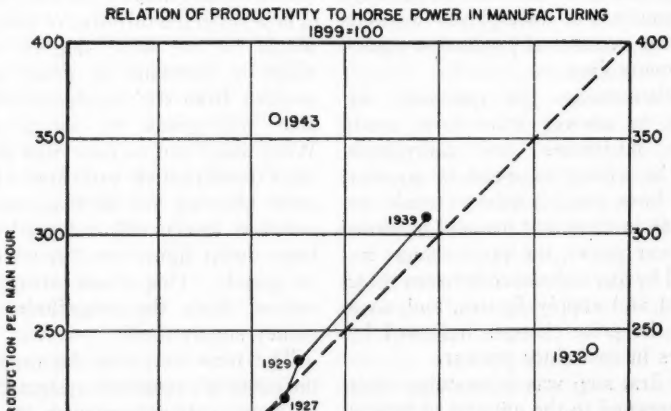
The next step was the capacity of the country's economic system in terms of gross national product at prewar prices. Estimates of this sort had been made by several prominent economists, on the assumptions of full employment of the labor force and a continuation of prewar trends toward increased efficiency. These estimates varied rather widely, and since we wanted a minimum figure on the probable price rise—one which might be exceeded, but would not lead us astray by being ex-

cessive—we selected one of the higher estimates of capacity.

By comparing our various estimates of willingness to spend in terms of *current* prices with this estimate of productive capacity in terms of *prewar* prices, we were able to secure a range of estimates of the probable increase in the general price level. These estimates ranged, for the early postwar years, from a minimum increase over 1940 of about 60 percent to a remote possibility that prices might rise to three times their 1940 level, with the odds strongly favoring something around the minimum 60 percent figure.

As a check, we compared the history of prices for manufactured goods with the history of unit labor costs and raw material prices. We found, first, that up to the beginning of wartime price control there had been a very close correspondence between labor and material costs and the prices of manufactured goods, and second, that during the war costs had increased to the point where they indicated a 40 percent increase over 1939 in the average price of all manufactured goods, whereas actual prices had increased only a little over 20 percent. This indicated a strong upward pressure on the prices of manufactured goods, a pressure which has since been reinforced by further increases in wage rates and material prices.

This study had some valuable by-products in a general picture of the probable course of events early in the postwar period. Since it appeared that



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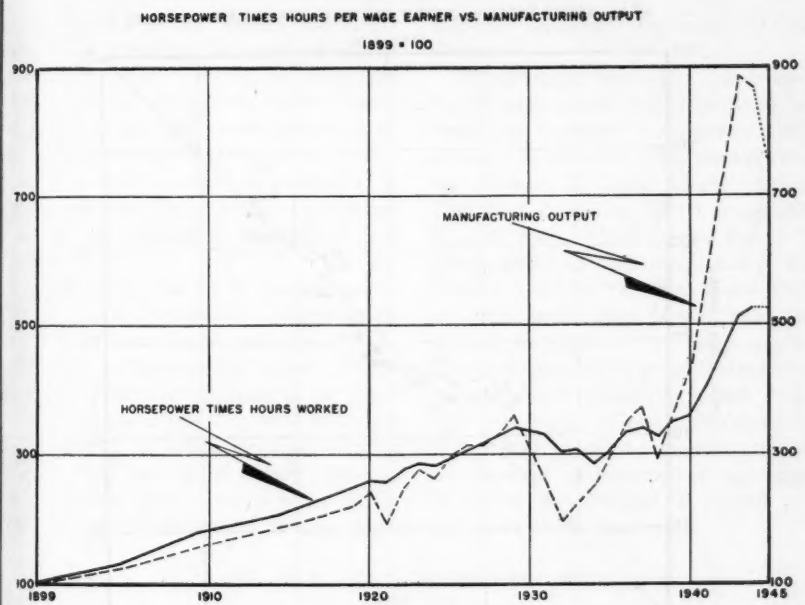

CHART II

willingness to spend money for goods would be very great and in excess of capacity even at full employment, it followed that unemployment would probably be minor, except for the frictional difficulties of plant reconversion, troubles in securing materials and equipment, the rapidity of demobilization and labor disturbances. It also followed that pressure to expand capacity would be very great, indicating great activity in capital goods lines and non-residential building. Further, a rigorous price control program, if it were attempted, would simply shunt goods into black market channels, with bootlegging of all varieties of goods surpassing the heyday of the prohibition era, since a public with over-abundant money would seek out scarce goods. This picture seemed so clear that we were considerably taken aback by the Washington reconversion program of fostering wage increases to bolster purchasing power while attempting to hold a tight lid on prices despite the increased pressure of higher costs.

Our check on our price estimates had led us into the matter of unit labor cost in manufacturing. Unit labor cost is the quotient of hourly wage rates and the physical units produced per man-hour. This production per man-hour is also known as productivity, and because it is of such basic importance we pursued its study further.

Much of the discussion of productivity runs along two lines: first, that productivity is primarily a matter of the effort and morale of workers and second, that there is some sort of inherent trend toward increased effi-

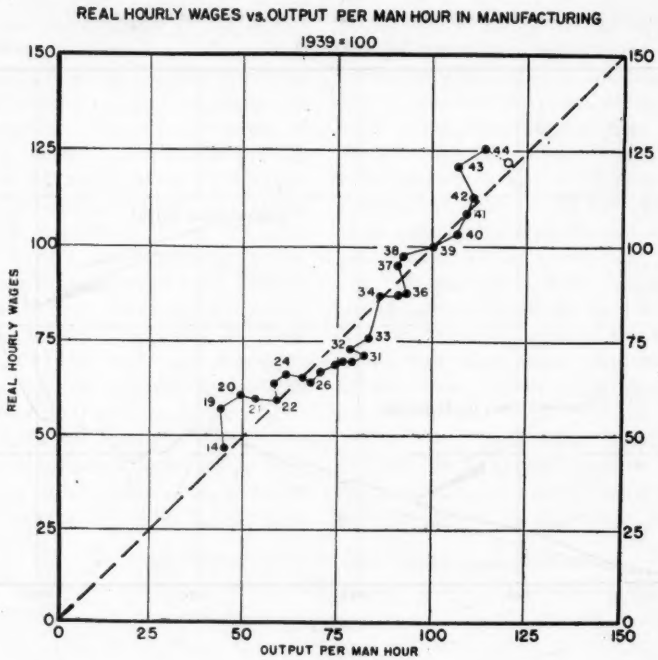

CHART III

ciency which expresses itself in a cumulative gain of around 2 percent per year.

While granting the importance of workers' effort and morale in the day-to-day and month-to-month variations in their efficiency, we found that output per man-hour in manufacturing in 1939 was roughly double that of 1919 and roughly triple that of 1899. It seemed unreasonable to suppose that 1939 workers worked twice as hard as their forebears in 1919 or three times as hard as their forebears in 1899. Similarly, we found it hard to believe that the mere passage of time could increase efficiency, so we were forced to turn elsewhere for explanations.

The tentative explanations of increased productivity in manufacturing which we have found so far should be of special interest to engineers. On the side of mechanization are the application of increased power per worker and improvements in machines—greater speed, precision and specialization, with expanded use of jigs and fixtures to transfer the requisite skill and consistency of performance as far as possible from the worker to the machine. Under the heading of industrial techniques are improved designs, simplification and standardization of products, refinements of materials, development of new processes (for example, extrusion, die-casting, powder metallurgy, electronic heat-treating, etc.), better plant layout and flow of work, improved material handling equipment, job analysis, time and mo-

tion study, quality control and many others. Affecting the performance of the individual worker are improved lighting and ventilation, higher standards of health and safety, job training for the development of skills, sundry security and recreation programs to improve morale and incentive programs to induce maximum application and effort.

Pervading this whole list is the influence and achievement of engineering in its various forms and applications. The team of investor, manager and engineer appears as the basis of the great strides made in our industrial efficiency and power in recent decades—strides which, as I shall shortly show, underlie the corresponding increase in living standards which has made the rank-and-file American the envy of the world.

Of particular interest in the foregoing list is the close correspondence between the increased horsepower made available to manufacturing workers and the increase in their hourly output. The chart shows the figures from 1899 through 1939. The dashed line indicates a point-for-point relationship; the sharper slope of the data since 1919 indicates that other factors than increased horsepower per wage earner have also operated to raise productivity, but the general similarity is still striking. For eight different combinations of terminal years, the median ratio of the increase in horsepower per wage earner to the increase in output per man-hour is 80 percent.

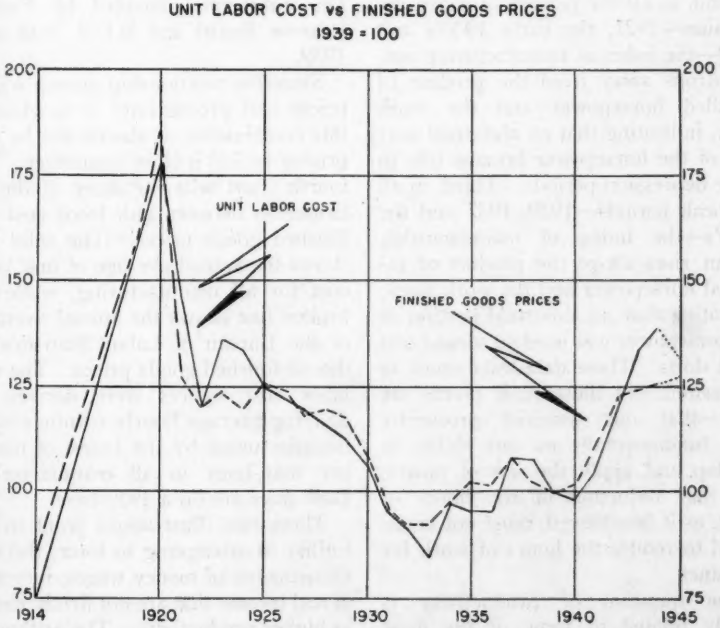

CHART IV

As a corollary to this exhibit, there should be a fairly close relationship between installed horsepower in manufacturing, times the hours per week it is used, and the physical volume of manufacturing output. The second chart shows the result of this comparison. All the data are index numbers based on 1899 as 100. The solid line is the product of an index of installed horsepower in manufacturing and an index of actual weekly hours per wage earner in manufacturing. The broken line is an index of manufacturing output, as reported by Fabricant, from 1899 to 1939, and by the Federal Reserve Board since 1939. Three areas of divergence merit special attention. First, between 1909 and the early 1920's there is a persistent gap of about 20 points between the two lines. Second, in all the periods of sharp depression—1921, the early 1930's and 1938—the index of manufacturing output drops away from the product of installed horsepower and the work week, indicating that an abnormal portion of the horsepower became idle in those depression periods. Third, in all the peak periods—1929, 1937 and the 1940's—the index of manufacturing output rises above the product of installed horsepower and the work week, indicating that an abnormal portion of the horsepower was used on second and third shifts. These data leave much to be desired, but these basic points are clear—that our material prosperity rests fundamentally on our ability to develop and apply the use of power, and that reduction of the hours of labor, as it is achieved, must not be allowed to reduce the hours of work for machines.

The question of productivity is closely related to some of the most burning economic issues of the day. A concerted drive is on to increase the purchasing power of organized labor, and the accent on *real* purchasing power, in terms of goods and services, is evident in the insistence that wage increases shall not be reflected in price advances. Yet from the past record the evidence is clear that advances in real hourly wages have been closely tied, for at least three decades, to advances in output per man-hour. The data are shown in the third chart. Here again the dashed line indicates a point-for-point relationship. The data are index numbers on a 1939 base; the real income data are Bureau of Labor Statistics figures on average hourly earnings in all manufacturing divided by the B.L.S. cost-of-living index, while the output per man-hour figures are the same as were used before, from Dr. Fabricant, extended by Federal Reserve Board and B.L.S. data after 1939.

Since the relationship among wages, prices and productivity is so close in this combination, it should not be surprising to find it close in another. The fourth chart tells the story of the relationship between unit labor cost and finished goods prices. The solid line shows the annual average of unit labor cost for all manufacturing, while the broken line shows the annual averages of the Bureau of Labor Statistics index of finished goods prices. The unit labor cost figures were derived by dividing average hourly earnings in all manufacturing by the index of output per man-hour in all manufacturing. Both lines are on a 1939 base.

These two illustrations point to the futility of attempting to force, through adjustments of money wages, increases in real income that are not firmly rooted in higher productivity. The arithmetic is simple and inexorable; whatever in-

crease in cost is appropriated by one group must be paid for by others; it must either be squeezed out of profits or paid for in higher prices. The only way to increased real income—the goods and services of our daily lives—lies in achieving greater efficiency, greater output per hour of work, and distributing the gains equitably among the whole population. This is the economic mission of the engineer, and the sooner and more forcefully it can be brought home to him in his academic training, the better off we shall all be.

Mathematics Beyond Calculus for Engineering Students*

By FREDERIC H. MILLER

Professor and Head, Department of Mathematics, The Cooper Union School of Engineering

Recent far-reaching technological advances have done much to emphasize the importance of mathematics in engineering. Like the pure physical sciences which constitute the foundation of engineering, applied science and technology are tending to become more and more quantitative and analytical. The increasing complexity of engineering problems that arises when additional variables are taken into account demands the increased use of analytical methods, and advanced mathematics affords a powerful and indispensable analytical instrument.

Evidence of the extensive application of advanced mathematics in modern engineering can be found in nearly all the professional and technical periodicals. A recent examination of the journals on a rack in the Cooper Union Library, all of them current at that time, revealed papers in which the following mathematical topics played essential roles:

A.I.Ch.E. Transactions—Curve fitting and the method of least squares.

A.S.C.E. Proceedings—Infinite series, hyperbolic functions, partial differential equations.

Electrical Engineering (A.I.E.E.)—Operational calculus, infinite series, hyperbolic functions, partial differential equations.

I.R.E. Proceedings—Partial differential equations, dimensional analysis, vector analysis, operational calculus, hyperbolic functions, Fourier series, contour integration employing complex variables, Bessel functions.

Mechanical Engineering (A.S.M.E.)—Vector analysis.

Journal of Applied Mechanics (A.S.M.E.)—Ordinary and partial differential equations, hyperbolic functions, functions of a complex variable, elliptic integrals.

Industrial and Engineering Chemistry—Partial differential equations, Bessel functions.

Journal of Aeronautical Sciences—Hyperbolic functions, partial differential equations, infinite series, dimensional analysis, operational calculus.

Let me emphasize the fact that this is merely a partial list obtained from periodicals all of which were published within a single two-month period chosen at random. I believe this offers convincing evidence that advanced mathematical analysis is indispensable in modern engineering, and that the engineer who wishes to keep abreast of new developments and techniques by reading his professional journals needs a sound training in mathematics

* Presented at the Conference on Mathematics, S.P.E.E. meeting, St. Louis, June 20–23, 1946.

that goes well beyond the conventional course in calculus.

In the engineering curricula of the past, the final mathematics subject offered to the student was, in most cases, differential and integral calculus. With the growth of modern engineering practice, curricula began to include a first course in differential equations, and in some engineering schools today that subject forms the culmination of the student's mathematical training. In various curricula one finds listed—as required, recommended, or purely elective subjects—certain special topics, such as vector analysis, advanced calculus, or advanced differential equations; in others, the attempt is made to meet the need of tomorrow's engineers by offering a course which may be simply entitled "Advanced Mathematics" and which has quite broad objectives.

Before commenting on these subjects, I should make clear my working definitions and premises; these are as follows:

1. Mathematics up to and including calculus is here regarded as elementary, and prerequisite to all further work in mathematics and its applications. The treatment of elementary mathematics for engineering students may differ little from that for other types of students.

2. Mathematics beyond calculus may be called advanced. The treatment of all advanced mathematics for engineering students, as well as the content and nature of the subject matter, should be in accord with the fundamental fact that it is to be useful to the engineer, either in direct application or as training in analytical thinking.

3. The primary aims of advanced mathematics for engineers should be the cultivation of the abilities to reason logically, to analyze physical problems, and to recognize the unifying aspect of mathematical analysis whereby a single mathematical formulation may be given several diverse physical interpretations.

I cannot hope that everyone will subscribe wholeheartedly to these statements, and even where there is general agreement there may be the belief that I have ignored other considerations that are of equal or perhaps greater importance. However, for my present purpose these brief remarks will perhaps serve as a basis for discussion.

With regard to the subject of differential equations, several comments may be made in line with my premises. As it is sometimes given in engineering courses, this subject is open to the danger that the treatment may be too detailed; special types of differential equations that rarely, if ever, arise in engineering work are given undue attention merely because they may be subjected to "elegant" methods of solution (which often depend upon tricks or ingenious devices), or because they have geometric interprtations that are of interest (at least to some mathematicians). As a consequence of the above fault or for other reasons, inadequate attention is sometimes given to the formulation of physical situations in their natural mathematical guise of differential equations; when properly treated, such problems should entail a careful consideration of the underlying physical principles, the matter of physical units and dimensions, the algebraic signs attached to various terms, etc. A third point that I believe deserves comment is the desirability of including some experience with differential equations that stem from physical problems and which cannot be solved in simple closed form, so that approxima-

tion methods or infinite series solutions must be employed. In addition, it seems to me that, since many physical problems with engineering applications involve more than one independent variable, some work with linear partial differential equations and boundary value problems should be included; little or no attention is given to such matters in many a first (and unfortunately sometimes last) course in differential equations.

I have discussed at some length the specific subject of differential equations because it is, to my mind, the basic topic in advanced mathematics for engineering students. Let us now consider briefly these two general questions:

1. Should our courses be of the formal or applied type?
2. Should our courses be concerned with special topics or with broad analytical methods?

In the first question I mean by a formal type of course one containing little or no engineering applications but instead placing major emphasis on purely mathematical questions: existence theorems, precise statements of necessary and sufficient conditions, function-theoretic points of rigor, etc. At the opposite extreme we have the type of course in which all the fine mathematical points are taken for granted, and only those matters which have application in a specific branch of engineering are given consideration. A course in advanced calculus that is actually the theory of functions of a real variable, given by a mathematician who has little knowledge of, or interest in, engineering problems, might be an example of the former type; a course labeled vector analysis that is actually field theory, given by an engineering teacher who is only too willing to leave proofs, derivations, and critical analyses to the mathematician, might be an extreme example of the latter type.

Probably the only reasonable answer to the first question is that our course should be a judicious mixture of the two types. If I were pressed to say what percentage of each constitutes a judicious proportion, I should have to counter first by asking what other subjects are included in the curriculum and then by attempting to devise a course that I could exhibit as my idea of a proper blend.

The second question is intimately connected with the first. A course may be concerned with one specific subject, such as vector analysis, or it may be offered only to students in one branch of engineering and its applications accordingly limited to that field. On the other hand, a course may be broad enough to introduce, at least, a variety of topics, and such that its methodology and its applications are of value to many branches of engineering.

When confronted with this question, I can make my choice without hesitation: I firmly believe the broad type of course to have greater educational value than any single-topic course. There are, I believe, several cogent reasons for such a choice.

First of all, a broad-gauge course in advanced mathematics is in line with the trend toward overall broadening of engineering education, as stated in the 1940 Report on Aims and Scope of Engineering Curricula: * "Undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic and social studies." This

* JOURNAL OF ENGINEERING EDUCATION, Vol. 30, No. 7, March, 1940.

is reaffirmed in the 1944 Report of the Committee on Engineering Education After the War,† where we also find the statement: "It is especially clear that the attempt to make the undergraduate student proficient in specialized subdivisions of engineering practice must be abandoned in the interests of developing mastery of basic principles."

In addition, it should be recognized that the engineering graduate may ultimately become engaged in various kinds of engineering practices that are not directly related to his chosen field, and that he should therefore be equipped with the ability to apply basic physical and mathematical principles to diverse types of problems. Even if the young engineer is not often confronted with problems outside his field, he should be in a position to read and understand the papers in his professional journals, the wide range of which has previously been remarked upon. Finally, it seems to me that a well integrated course in advanced mathematics will best serve to inculcate unifying principles of wide and general applicability.

All of the above remarks have served, I hope, to lay the foundation for the consideration of our main point of discussion. If we attempt to construct, develop, and administer a well-balanced course or sequence of courses in advanced mathematics for engineering students, what should be our objectives and what should constitute the content?

Without attempting to go deeply into the question of objectives, I may set down the following points which seem to me to be of paramount importanee :

1. The course should, above all, aim to develop the ability to formulate a physical problem in mathematical terms.

2. Analytical ability to deal with mathematical forms should be strengthened.

3. The student should develop the ability to interpret mathematical results physically, to use the results computationally, and to deduce physical relations and quantitative relationships.

4. The student should acquire an increased appreciation of the unifying character of mathematics and its value as an analytical instrument for dealing with general principles.

5. The course should impart to the student sufficient familiarity with the terms, notations, concepts, and techniques of advanced mathematics to enable him to read with understanding the technical papers in engineering books and periodicals.

I believe that the subject of differential equations, if it is presented in such a way as to avoid the dangers and shortcomings previously mentioned, can do much to meet the first three objectives. But in order to achieve a fair measure of success with the remaining two objectives it is necessary, it seems to me, to broaden the content of the desired course. Accordingly, I think the question of content will be best answered in the following manner.

The starting point for advanced mathematics should be a good treatment of ordinary differential equations. This subject is the natural outgrowth of calculus and is at the same time the basis of much additional applied mathematics. The treatment should be restricted to the consideration of a few simple types of frequent occurrence in physics and engineering; artificial prob-

†JOURNAL OF ENGINEERING EDUCATION, Vol. 34, No. 9, May, 1944.

lems which can be solved only by trick methods should be avoided. Whereever possible, the three phases of the overall physico-mathematical problem—formulation of the differential equation or equations from basic physical principles, solution by suitable mathematical techniques, and interpretation and application of the resulting functional relations—should be given prominence. Approximation methods and solutions in infinite series should also be given proper consideration.

With this kind of foundation, new and powerful kinds of functions can be naturally introduced and advantageously applied. For example, hyperbolic functions, elliptic integrals and functions, Bessel functions, and functions of a complex variable all stem from quite simple physical problems and their corresponding ordinary differential equations. Probably none of these topics can be given anything like an exhaustive treatment in the limited time available in an undergraduate curriculum, but I believe it is possible to meet the principal objectives and to provide a good basis for later independent reading and study.

Next may be mentioned the subject of partial differential equations. Here the treatment may be limited to linear homogeneous equations, to which the method of separation of variables and the superposition principle apply. Boundary value problems are of great importance to the engineer; these provide, as do similar problems involving ordinary differential equations, excellent examples of the three-fold problem of formulation, solution, and interpretation. In connection with partial differential equations, the subject of Fourier series comes to the fore as a powerful and useful tool, and trigonometric series should therefore be introduced and applied.

The elementary theory of functions of a complex variable should also, I believe, find a place in engineering education. The applicability of conformal mapping to field problems of many kinds and the usefulness of contour integration can properly be given consideration.

In addition to the broad and fundamental subjects just mentioned, there are, of course, numerous other topics that can well be included whenever time permits. Among these may be mentioned gamma functions, vector analysis, probability, the method of least squares as applied to curve fitting, and operational calculus. With regard to such concepts, some acquaintance, at least, with relevant definitions, symbolisms, and properties is desirable. Even a brief introductory treatment will serve to give the engineering student the necessary feeling of familiarity with the material when it is encountered in his subsequent reading of professional literature.

In connection with the application of all the mathematics mentioned, I believe that the range should be made as wide as possible. Problems in dynamics, mechanical and electrical vibrations, heat flow, the flow of fluids and electricity, chemical solutions, flexure of beams, etc., etc.—as many of these as possible should form the common experience of every engineering student, whatever his field of study. Only in this way can all the stated objectives be adequately approached.

Courses modeled along the lines described have been given to classes in The Cooper Union School of Engineering for the past ten years. These courses are still in process of development, so that they differ in details from

year to year, but we like to think that they are steadily approaching the ideal fulfillment of our objectives. If, through courses in advanced mathematics for engineering students, we can help to broaden and at the same time deepen our educational program, we will, I believe, help in some measure to meet the present and anticipated need for engineers who are prepared to practice their profession at a high scientific and creative level.

Summary of Information Concerning Humanistic-Social Courses in Engineering Colleges*

By LISLE A. ROSE

Director of Public Relations, Michigan College of Mining and Technology

The information here summarized was gathered by questionnaire. We are all aware of the disadvantages of this method of getting data, particularly when it is contrasted with the method of inspection and detailed examination as used, for example, by Messrs. Boarts and Hodges in their recently reported study of what eight engineering colleges are doing to implement certain major recommendations of the Committee on Education after the War —the so-called Hammond Committee.

For aid in overcoming as far as possible the weaknesses of the questionnaire method, I am indebted to those S.P.E.E. officers and members who at my request criticized the original wording of the questionnaire. I am also greatly indebted to the scores of administrative officers in engineering colleges who graciously and conscientiously filled out the questionnaire. All did so at a sacrifice of time and effort; many did so at a date for whose lateness I am responsible.

One hundred twenty-three universities and colleges which are Active Institutional Members of the S.P.E.E. were queried; four highly specialized institutions were not.

As if to make the figuring of percentages easy, exactly 100 usable replies were received. Men from a few other schools expressed agreement with the aims of the "Hammond Committee" of 1944; some of these, however, said that they did not see their way clear to fulfilling most of those aims.

The percentage of usable replies received did not vary greatly from one to another of the nine regions into which the census divides the United States. Twelve of the 13 New England institutions which were queried, replied; 23 of 27 Middle Atlantic; 11 of 14 South Atlantic; 14 of 18 East North Central; 10 of 13 West North Central; 5 of 7 East South Central; 7 of 10 West South Central; 11 of 13 in the Mountain States; and 7 of 8 on the Pacific Coast.

The first block of questions which I asked was concerned with what we may call the quantitative response to one of the Hammond Committee's recommendations—specifically, to that which urged that approximately 20 per cent of the undergraduate engineering-student's time be devoted to humanistic and social-science studies. You recall that the Committee did not favor considering any purely "tool" subjects as in the humanistic-social category. You recall likewise that not only a few economics but a few English and other courses that are re-

* Presented at the 54th annual meeting, S.P.E.E., St. Louis, June 20–23, 1946.

garded by some as humanistic, seemed to the Committee undeserving of that classification, because either narrowly utilitarian or often taught by sheer drill and repetition.

To my first question was therefore appended a note which asked, in substance, that the term "humanistic-social" be construed rather rigorously.

The first question itself read as follows: "Of the total credits required for an undergraduate engineering degree, what percentage must now be taken in humanistic-social science subjects?"

The second question read: "If the percentage varies within your institution, please indicate what it is for each curriculum or branch."

Fifty-five per cent of the hundred institutions report no variation, or a negligible one, from curriculum to curriculum. On the other hand, 17 schools report a quite considerable variation, and 28 others report *some* variation. The replies do not show that, the country over, any particular branch or branches of *engineering* are most likely to require a high, *or* a low, percentage of the humanities and social sciences. It is to be noted, though, that curricula in management are, as would be expected, an exception to this statement.

The greatest variations within institutions are reported from one school in the West South Central region, where the range from branch to branch of engineering is 0–15 per cent; and from a New England college, with a range of 7–24 per cent.

Four of the seven West South Central schools show variations; four of the eleven South Atlantic.

Two schools—one Middle Atlantic and one Rocky Mountain—require of their students no humanities or social sciences. Seven schools require less than 5 per cent humanities and social sciences, ten require between 5 and 10 per cent.

But 51 per cent of the institutions have the undergraduate engineer devote between 10 and 20 per cent of his academic work to the humanistic-social stem. The most common percentage—I avoid mathematical terminology—is 16. Thirteen institutions prescribe 20 per cent or more; a few of these have a five-year undergraduate course.

Sixty-four of the hundred institutions, then, are at or above 10 percent; 41 are at or above 15 per cent.

In the South Atlantic region 8 of 11 institutions are at or above 15; in New England, 7 of 12; in the Middle Atlantic states, 12 of 23 (with four more between 12.5 and 15 per cent); in the East North Central region, 7 of 14 (with one other above 15 per cent for some of its curricula).

No significant differences are visible on the whole between publicly supported institutions and private ones. But, as I think we would expect, the Catholic colleges and universities which replied do require a fairly high percentage of humanistic-social subjects.

Nor can I see trends within any of the states of the Union.

Correlations not now discernible might become apparent if we were to classify the institutions according to the *economic sub-regions* in which they are located. One reason for believing so is that most of the institutions which originally were—and some of which still are—mining colleges almost entirely, require of their students a smaller percentage of humanistic-social work than do other types of schools. The mining institutions, moreover, ap-

pear to find even more difficulty than most in raising the percentage.

As I implied a moment ago, a note to Question I asked that there be excluded from the computation "the introductory drill-course in English composition; such business courses and economics-skills courses as accounting, engineering cost analysis, banking principles, and the like; and those foreign-language courses which are taught solely as engineering 'tool-subjects.'"

To allow for differences of interpretation, a question was devised which read: "If you feel that any course or courses named in the note to Question I, or any parts of those courses, are humanistic, please indicate what statistical revisions you would make in your report."

Sixteen institutions took advantage of this offer, so to speak, and proposed an upward revision in their percentages. All regions except New England would be affected by this change. The greatest increase would occur in the figures for the Middle Atlantic states and the Rocky Mountain states.

English composition courses in particular were added by most of these sixteen schools.

The problem of classifying foreign languages also proved troublesome to certain institutions, my own included.

Another subject of interest to us engineering educators is the effect of the two S.P.E.E. reports—those of 1940 and of 1944—on the policy of engineering colleges.

To sum it up briefly, both reports had a decided effect.

Two Atlantic Seaboard colleges which were at or near the 20 per cent figure in 1939, have since added humanistic-social courses and plan to add still more.

Two institutions which, after the publication of *each* of the reports, added to the humanistic-social stem are planning a still further increase.

Some half dozen colleges, in five regions, added to the required subjects in their humanistic-social curricula after the publication of each report, but plan no further additions. Two or three, though, do plan further changes in teaching approach and methods.

Eleven institutions which added to the humanistic-social stem after one or the other S.P.E.E. report are planning further additions. These 11 colleges are located in eight regions.

Twelve institutions in six regions feel that between 1940 and 1944 they added all the humanities and social sciences which their four-year curricula will bear. Some of these institutions are below 10 per cent in time devoted to the humanistic-social stem.

Eighteen institutions which increased their required humanistic-social science offerings after June of 1944 believe that they have reached their limit under their present program.

Obviously, this ties in with the problem of a five-year undergraduate program. Eight of the hundred schools were already on such a program, cooperative or other, at the time the 1944 report was presented; and, as we all know, many of these eight had been following that program for a long time.

Three institutions replying have adopted a five-year program since 1944. One of these is offering it for *non*-veterans.

Ten others are seriously considering such a program. They are located in six of the nine regions. Four more schools see no solution except a five-year program, but are not planning as yet to adopt it.

The institutions were also queried

regarding some of the corollary suggestions made by the Hammond Committee, and were asked to indicate which of these they had put into effect and which they were planning to put into effect.

Thirty-seven per cent have been laying emphasis on the development of good citizenship, and twenty-five others plan to stress this. Forty-one have emphasized the humanistic and social bearings of engineering courses wherever possible, during instruction in those courses; twenty others plan to do so. Forty-five have reinforced their curricular work by voluntary student activities; seventeen others plan to do so. (This question was intended to relate to the use of extra-curricular time in promoting interest in the humanities and social sciences; my clumsiness in phrasing the question, however, makes me doubt that it *was* always so interpreted, and therefore the figures are not as meaningful as I had hoped.)

Two other proposed methods for handling humanistic-social instruction were named in the questionnaire. One is a synthesis of humanistic and social-science subject matter in one or more courses—for example, a course in The Development of American Civilization. Twenty-one colleges reported using this method, and 17 plan to. A three-way synthesis, however—a synthesis of humanistic, social-science, and technological subject-matter in one course —, met with much less favor. Only seven schools report having done this; eight are interested in trying.

The last question which brought forth any considerable percentage of replies dealt with obstacles encountered and anticipated in putting the Hammond Committee's recommendations into effect.

Of course, lack of time was the biggest drawback. Forty-six per cent had met this obstacle; 21 per cent were sure they would.

Twenty-two per cent had met objections from their technical staffs—particularly in the East North Central, Mountain, and Pacific regions. Eighteen per cent anticipated such objections.

A very small percentage had met opposition from members of the humanistic-social science staffs.

Eleven per cent had met objections from within the student body; 13 per cent expected to do so.

Among miscellaneous obstacles to implementing the Hammond Committee recommendations should be mentioned the amount of time required, or perhaps to be required in the postwar period, for R.O.T.C.; criticism from the press; and criticism from industry.

The general picture is one of some natural differences of interpretation as to the humanistic nature or bearing of certain academic courses; a fairly common though not, apparently, a dominant feeling that a five-year curriculum is required in order to achieve the Hammond Committee's aims without weakening the technical branches; serious difficulties encountered by certain types of colleges, and by directors of certain engineering branches in many colleges, in putting the recommendations into effect; but very widespread earnest efforts to implement the basic proposals made by the Hammond Committee.

Effect of the War on Co-operative Education*

By LEO F. SMITH

Chairman, Education Research Office, Rochester Institute of Technology

The War produced many changes in educational programs in higher institutions some of which were temporary and others of which will undoubtedly prove to be more lasting. In the effort to discover the effect of the war on co-operative education the author recently made a quick survey to determine the following: (1) The number of programs which had been continued during the war; (2) the programs which had been discontinued; (3) significant changes which were being planned in co-operative programs; and (4) plans for co-operative programs in institutions which had not previously been carrying on this type of education.†

A previous study made by the writer revealed that during the school year 1940–41, 29 colleges‡ and universities and 3 technical institutes had co-operative programs. In the current study a personal letter was sent to the individual in charge of the co-operative program in each of the institutions. Four questions were raised in the letter: (1) Did you attempt to carry on your program during the war years? (2) Are you planning on continuing with your co-operative program during the coming years? (3) Do you plan on any new co-operative curricula, or any other significant changes, such as, a different period of alternation or improved methods of co-ordination? (4) Do you know of any institutions other than those listed in the enclosed reprint † which now have, or are planning co-operative programs? A 100 per cent response was received to these personal letters and the replies varied from 1 to 4 pages in length.

Co-operative Programs During the War Years

Seventeen of the colleges and universities indicated that they had continued their programs during the war years. These institutions were: Alabama Polytechnic Institute, Antioch College, University of Buffalo, Carnegie Institute of Technology, University of Cincinnati, Cleveland College of Western Reserve University, University of Detroit, Drexel Institute of Technology, Eureka College, Fenn College, University of Florida, Georgia School of Technology, Massachusetts Institute of Technology, University of Minnesota, Northwestern University, New York University, and Southern Methodist University.

Two of the three technical institutes, Rochester Institute of Technology and Wyomissing Polytechnic Institute, also carried on their programs.

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* Reprinted from *Higher Education*, Vol. II, No. 14.

† Leo F. Smith, "Co-operative Education in Colleges and Universities," JOURNAL OF ENGINEERING EDUCATION, Vol. 35, pp. 395–400, March 1945.

‡ Mississippi State College had inaugurated a co-operative program in the School of Engineering in 1939.

All of the institutions which had carried on their programs indicated that it had been with a greatly reduced enrollment, and several had opened up the engineering courses to women students.

The following institutions indicated that they had discontinued their programs during the war years: University of Akron, Bradley Polytechnic Institute, Illinois Institute of Technology, Lawrence Institute of Technology, University of Louisville, Marquette University, Newark College of Engineering, North Carolina State College, Northeastern University, University of Omaha, University of Tennessee, and University of Tulsa. Ohio Mechanics Institute was the only technical institute which had discontinued the co-operative program during the war years.

The two major reasons advanced for discontinuing these programs were that Selective Service would not grant deferment to students on a co-operative program—hence necessitating an accelerated program; and several of the institutions had devoted their entire staff and facilities to training programs for the Army and the Navy.

Institutional Plans for the Post-war Period

It is significant to note that all of the institutions (with one possible exception) which had co-operative programs prior to the war are planning on continuing with these or re-initiating them as soon as possible. Several schools which had discontinued their programs during the war had already started these programs again in September 1945, and all of the remaining institutions expected to have the programs under way by September 1946.

Another factor of interest is the tendency for all institutions to use a quarterly or semester period of alternation. For example, the University of Detroit has already changed from a 4-week to a 12-week period; Illinois Institute from an 8- to a 17-week period; Marquette University will probably change from 1 month to 3 months; Southern Methodist may change from a 6- to a 12-week period; and the University of Omaha is shortening the period from 6 months to not more than 3 months. The Rochester Institute of Technology has also lengthened the period from 4 to 10 weeks in three of the five departments carrying on co-operative work.

Several institutions are planning on an expansion of the number of co-operative curricula. Alabama Polytechnic Institute is increasing its number of co-operative curricula from 6 to 17. These new curricula are: Aeronautical administration, aeronautical engineering, agriculture and banking, building construction, business administration, chemistry, engineering physics, industrial management, laboratory technology, pharmacy, and textile chemistry.

Bradley Polytechnic Institute inaugurated seven co-operative programs at the technical level in February 1946. These are on the basis of 16-week alternations of four terms each, and the curricula offered are: Chemical engineering aide, electrical engineering aide, engineering drafting aide, engineering inspection aide, industrial engineering aide, mechanical engineering aide, and metallurgical engineering aide. The University of Cincinnati offered a 3-year certificate program for chemical technicians during the war and will probably continue it if there is sufficient demand. The Rochester

Institute of Technology inaugurated a new 3-year curriculum in tool engineering in 1945 and plans on a new 3-year curriculum in printing and publishing, beginning in September 1946.

Several institutions are making plans to speed up the program for returning veterans by offering full-time programs as well as co-operative programs. At the Rochester Institute of Technology, veterans have been required to take the regular co-operative program; and, although it is still too early to generalize, they appear to be well satisfied with the work experience and to appreciate its value.

New Co-operative Programs

In the current study four new co-operative programs were discovered that were not reported in the earlier study. These are: University of Denver, Mississippi State College, Rensselaer Polytechnic Institute, and Stevens Institute of Technology.

At Denver, the co-operative work is offered in the College of Engineering. The program was officially initiated in September 1944, and is available in chemical, electrical, mechanical, and commercial engineering. The industrial phase of the plan comes during the last 3 years of the 5-year program, and, consequently, the first group of students will go into industry next June. The period of alternation is 3 months. At present the co-operative feature will be optional for the veterans attending the University of Denver.

The program at Mississippi State College was inaugurated in the School of Engineering in 1939, and the curricula included electrical, mechanical, and civil engineering. All students attended the first semester at college and then alternated on a semester basis. The course was 5 years in length and the co-operative work was offered in all years except the first semester. The program was dropped during the war, but it is expected that it will be resumed in the fall semester of 1946.

Rensselaer Polytechnic Institute initiated its program in September 1945. The plan is adaptable to any of the fields in which the Institute offers curricula, but at present definite arrangements have been made with only one company. The students are in full-time attendance during the freshman and the senior years. The program is normally intended as a 5-year program culminating in the master's, as well as the bachelor's, degree; but, under special circumstances, it is possible to terminate the program for any given group with the completion of the requirements for the bachelor's degree. Each school and work block is 16 weeks in length, and a student completing the full program would have had 64 weeks of industrial experience.

Stevens Institute began its program in September 1942, but discontinued it in July 1943, when the establishment of a V–12 Unit on the campus and the increasing pressure from Selective Service boards forced it to a program of accelerated study. Under this plan students spent one 4-month term in industry and two in school during each 12-month period. At the time of this writing no decision had been reached as to whether Stevens would return to this program in September 1946.

Summary

It has been the purpose of this paper to summarize briefly the effects of the war on co-operative work programs. The principal findings are:

1. Seventeen of the 29 colleges and 2 of the 3 technical institutes maintained

their programs during the war, although with greatly reduced enrollments; and in several instances the programs were opened to women.

2. All of the colleges (with one possible exception) and technical institutes plan on continuing their programs in the coming years.

3. Four institutions with periods of alternation of less than one quarter or semester in length have increased the length of the school and work block. One institution which had a 6-month period of alternation is shortening this to 3 months.

4. Alabama Polytechnic Institute, Bradley Polytechnic Institute, the University of Cincinnati, and the Rochester Institute of Technology are expanding the number of co-operative curricula.

5. The University of Denver, Mississippi State College, Rensselaer Polytechnic Institute, and Stevens Institute of Technology had, or are planning, co-operative programs that were not previously reported.

Planning the Professional Aspect of the Humanistic-Social Courses

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The humanistic-social courses, if they are properly planned, can contribute directly to the technical phases of engineering education. This function is in addition to those of developing social consciousness and competence and giving a non-technical breadth of interest, and it gives promise of a much needed strengthening of scientific-technological work. It is my purpose to discuss this phase of the humanistic-social program—its direct relationship to the technical courses—and how to plan to accomplish this function. Planning is not so much a matter of subjects and hours but rather of educational method which is closely related to an understanding of function, hence the major part of this discussion is devoted to function.

A word as to point of view is in order. Since 1937 an integrated program of humanistic-social studies has been under development at Carnegie Institute of Technology. The planning activities have gone on continuously since the beginning; indeed, we are still planning and developing the program. The planning is done under the general direction of the Social Relations Program Committee, the membership of which is about half engineering teachers and half teachers in the humanistic courses. The engineering members are vitally interested in the progress of the humanistic-social work and feel a very real responsibility for its planning. But they are especially interested in its co-ordination with the technical portions of the curriculum. In the present discussion I speak both as one of the engineering members of the committee and as an engineering department head interested in the technical instruction of his students. The men working on this program have been so closely associated that it is difficult to say where the various ideas and phrases originated. Many of them have come from Robert E. Doherty, President, and Elliott Dunlap Smith, Provost.

The objectives of the humanistic-social stem of engineering education were stated in the 1940 Report of the S. P. E. E. Aims and Scope Committee and reaffirmed in 1944 by the Committee on Engineering Education after the War. Our work on the implementation of these objectives has led us to rephrase them as follows:

The basic objectives of the Social Relations program are to prepare the student in course to learn from subsequent experience throughout life to serve society, live his own life well, work with others, and broaden the ability, which is developed in his technical study, to gain fundamental understanding of principles and use that understanding resourcefully in the orderly treatment of problems.

The phrase "to prepare the student to learn from subsequent experience throughout life" is no accidental combination of words. An essential aspect of the planning is to devise courses to give not facts and answers but fundamental knowledge; and to help the student acquire for himself before graduation well-formed attitudes and a sense of responsibility which will impel his thought and action, and which will be factors in his philosophy of life and work, and to help him cultivate fundamental skills of thought and behavior which will enable him to learn continuously from experience how to make that philosophy effective. These skills should be so firmly established that whenever he encounters situations to which they apply, he will utilize them well without prompting.

Before undertaking my main thesis —the fourth objective—I wish, incidentally, to touch upon the third, preparation for working with others. This objective is closely related to the post-college development of the student into a mature engineer. In proportion as he attains professional stature and rises in his profession, he must deal with people and must assume the responsibilities of citizenship. In proportion as he becomes an administrator or consultant, the problem of dealing effectively with people and expressing himself with force and clarity in order to do so becomes a greater part of his work. In proportion as he becomes a leader in his community, he will be faced with responsibility for taking part in solving its problems. The humanistic-social program should therefore be planned to assist the student to learn how to apply engineering thoroughness and orderliness of thought to problems of dealing with people and with human institutions.

The fourth objective of the humanistic-social stem concerns the strengthening of the technical part of the program. To see what this means it is necessary to consider just what the engineering school is attempting to accomplish in the preparation of the student for the practice of his profession.

Professional engineering work involves much more than the mathematical application of engineering formulas or even of scientific principles. Insofar as an engineer does truly creative work, he must solve problems for which no formulations have been devised and make judgments from scientific principles in situations where mathematical manipulations cannot indicate the full solution. Even in less creative design and in operating work he must deal with the materials and forces of the real world, and these do not coincide exactly with the abstractions of pure science. Again and again he must deal with problems that involve indeterminate values and intangible factors, and he must make alternative and even speculative hypotheses. Yet in dealing with such problems, he must apply the same thoroughness and orderliness of thought that he applies to problems that are subject to mathematical solution. To learn how to do this well is both extremely difficult and extremely important.

In planning the humanistic-social program to fulfill this function as well as its others, we may well examine the technical courses to see what essential things are most difficult to accomplish in them. Perhaps the most important are a conception of planning the treatment of a problem in a broader sense than looking up a formula, the use of inductive approaches in mastering new material, and the realization that there

is usually more than one solution to a problem and a decision has to be made, not in absolute but in relative terms. These are precisely the factors that a suitably planned humanistic-social program can give real assistance in developing.

A most important step in analyzing engineering problems is the planning of the attack. It is easily slighted in a technical course, which in its day-to-day work necessarily is chiefly concerned with the details of the treatment. But with reference to problems as a whole it may be noted that when an engineering situation has been reduced to equations the solution of the problem has been placed in a mathematical straitjacket. At this point a plan of solution has been chosen, either with or without adequate thought, and thereafter the path to the answer is fixed. But some other treatment of the problem may have been more appropriate. It is important that the plan be selected consciously, after thorough deliberation and exploration of alternatives, rather than by chance and that the student be trained not to rush into a mathematical formulation. An engineer who worked with Steinmetz said that the chief difference between Steinmetz' approach and the ordinary engineer's was in the protracted depth of the analytical thought that Steinmetz could bring to bear on the problem before applying mathematics. However, this is not to deprecate the value of mathematics. The man with a greater command of that subject can solve problems in ways that others cannot. But in true engineering problems, of the sort that tax the masters of the profession, there is a non-mathematical part of the work which often requires more creative thinking than the mathematical part. It is just as important as the mathematics, or more so, for without it there is no sound basis for applying the mathematics.

The engineering student may not encounter such problems until several years after graduation. Indeed, this is a part of his difficulty and multiplies the dangers of preparing a student, as our programs so often do, for only the relatively simple apprentice work. The student is left to develop his own capacity for the handling of the truly professional work, in spite of the fact that industry usually of necessity assigns him in his early years to routine work in which there may be little opportunity and encouragement to develop a professional point of view and competence in creative thinking.

Humanistic-social courses can be made to provide an excellent medium for emphasizing the concept of planning the treatment in developing a disciplined form of non-mathematical thinking. This is true because these courses may be made, even in their early stages, to involve the doing of creative work for which the student can find no formulas and must devise his own plan or alternative plans of treatment. But to be effective in this respect the humanistic-social courses must, like technical courses, be built around problem solving. This, however, is not an additional requirement; problem solving elements are desirable for other reasons.

The fact that so often these courses, instead of calling for the disciplined solution of problems, permit a disorganized and haphazard form of thought should not prevent us from seeing the possibilities in these fields when they are properly handled. No one hates the type of drivel that one often gets on an essay question more than I do, but from personal participation in a fresh-

man course in English composition in which the students were asked to solve difficult problems in technical writing I am convinced that the thinking in humanistic-social courses can be as orderly and well organized as in any technical field. By insistence on this order in a non-technical area where it is so easy to be slipshod the student can get a flexible discipline in solving problems completely on his own that he cannot get in any other way.

I would like to illustrate by describing one of the problem assignments from an English composition class. The problem was based upon a hypothetical situation; the class was asked to order 100,000 pencils by telegraph using, however, complete sentences. A sample pencil was given to each student. The manufacturer was located in Iraq, where the particular type of pencil was not standard. The problem was to describe the pencil so accurately that it could be satisfactorily duplicated, yet without unnecessary precision and without unnecessary words. Decisions had to be made as to what properties were involved, such as size, shape, color, and hardness of lead. The planning of the treatment included considering the other fellow's point of view, what he was familiar with, and therefore in what terms the properties could be described to him. Size and shape offered relatively little difficulty; geometric terms are widely known and units of length are convertible. Colors were not so easy; to say that the pencils were to be yellow is not very precise. The casual students tried amplifying their initial approach and achieved terms such as deep yellow or very yellow, which may mean quite different things to different people. (So much of bad engineering is the result of carrying forward existing plans of treatment instead of devising fundamentally better ones to meet a new situation or to utilize new scientific or technical advances.) One thinking student reasoned that there would be lemons and oranges in Iraq, and he described the color he wanted in terms of their colors. Different means of describing color undoubtedly occurred to him and he had to select the most suitable of them. More difficult still is the specifying of desired hardness. One cannot be sure that the terms HB or Number 3 would convey the same impression to the Arabian as it would to the American manufacturer; indeed they might be meaningless. The same able student decided to make his specification of hardness in a rational way, in terms of supporting the sharpened pencil of definite weight and length at such a distance from one end that it made a barely discernible mark on paper under conditions of low light intensity, yet sufficient for reading.

After the treatment had been planned and the best plan selected, it was made effective by execution, in this case by expressing the description of the pencil in words with attention to clarity, brevity, and style. Then the result was checked as a whole. This may be accomplished by imagining oneself in the position of the person receiving the telegraphed order and testing for ease of understanding and for possibility of misunderstanding.

Another problem used in the same English course, in this case as a part of an examination, was the following: Write a definition of work, as the term is used in physics, for a high school student who has had no science courses and who has had no mathematics beyond arithmetic. The treatment in this case required first of all a clear

understanding of what the term means to a scientist, then a conception of what the high school student knows, and finally planning as to how the gap can be bridged. Two elements of planning are the extent to which illustrations will be used and the selection of the appropriate degree of precision. In this case one good solution started with the idea of a man pushing a rock, that is, with the everyday conception of what work is. The solution went on to point out that the scientific measure of work is not how tired the man becomes but is given in terms of the force the man exerts and how far the rock moves. That this kind of description involves orderly, and at the same time versatile and resourceful thinking, especially in the planning part of the solution, will be understood readily by anyone who has tried it.

Another way in which the humanistic-social courses can serve technical education, of comparable importance to training in planning the treatment of a problem, is in familiarizing the student with the inductive approach to problems—generalizing from experience. No student graduates with all knowledge; much of his capacity for professional work is founded on experience, which never comes in general terms, only by specific instances. And from experience one learns only inductively; experience is a teacher that uses the case method exclusively.

The social sciences, including law, have been proven by experience to be a field peculiarly suited to instruction by cases. At least some of the inductions of principle in the social sciences can be based on common experiences or upon very simple experiments, so that by giving the student carefully chosen instances he can be taught to practice the art of learning from experience in class, by making and delimiting generalizations under his own power. I have seen a very good example of this in a psychology class in the induction of the principles of attention. The whole process could be put into a single lesson. I wish one could say that the art of learning from experience is always developed in humanistic-social courses—unless care is taken the reverse is true—but it can be done, and it has an astonishing value when it is done. And the humanistic-social courses seem to lend themselves more readily to this training than the scientific-technological ones.

The preceding discussion has been centered around the contribution that humanistic-social courses can make to technical education, training in planning a treatment and in inductive generalization from experience. The emphasis has been on the one-way contribution from humanistic-social to the technical work. This leads us to inquire what common elements and what reciprocal relationships there may be that can be strengthened by suitable planning.

The committee supervising the Social Relations courses undertook to find a common method of approach to problems. At first glance it might seem that the differences in problem solving in the humanistic-social and scientific-technological fields would be greater than the likenesses. And so it seemed at the first committee meeting. But the subject was worked over and fought over and in the end an astonishing measure of agreement was reached. That is, whatever the field, one starts by defining the problem, collecting and analyzing the facts in relation to the original question in order fully to discover and delimit the situation. The second stage is planning the treatment: Determining what values, principles,

attitudes, and basic practices are applicable to the problem, and settling upon the means of dealing with the facts in the light of these ways of approach. The third stage is executing the plan so as to reach a decision, product, or result. Often the decision does not terminate the problem but clarifies or changes the issue so that work is begun anew. The fourth stage is checking the work as a whole, going over results systematically with reference to general knowledge and experience in the field, and then realistically in terms of use. Finally there is the stage of learning and generalizing the results, taking thought to see what in the treatment or result may be of use in future problems.

Along with this sequence of five stages: definition, planning, execution, checking, and learning, there are a number of other functions that should be performed as needed: simplification by restricting assumptions, alternation between analysis and insight, checking validity, and watching throughout for opportunities to improve by learning from experience.

It would be wrong to imply that problems, generally speaking, can be solved by any completely automatic sequence of operations, or that it is only necessary to teach such a formulation in order to turn out accomplished engineers. However, an organization of the pattern of thinking and mastering it through use is an important element of engineering education, as well as of engineering practice. In the case of a really difficult problem the difference between success and failure often lies in the recognition and use of such a method.

The fact that teachers in science and engineering could agree not only with each other but also with those in the humanistic-social courses on such a method provides a strong bond between the fields. That in both stems the students can be taught the same approach means the strengthening of the work in both and the possible economy of time. Whether the students should be given a formulation of the method or left to infer it from the teacher's handling of the subject is a debated question; either procedure seems to be able to produce useful and desirable results. But I believe that the pattern should be made explicit early, if not by inference then by presentation.

The emphasis on such a formulation in discussions between teachers brings another fruitful result. It makes the humanistic-social instructor more conscious of the problem work in his course and makes the engineer more aware of missing elements in his assignments. Whole problems, in the sense of involving the whole process of problem solving, are ones that involve all of the five stages—definition, planning, execution, checking, and learning—and the recurrent functions. Many if not most of the science and engineering assignments are fragmentary, in that they do not involve all of these, often confining themselves to the execution and checking stages.

While humanistic-social courses can contribute directly to professional education by teaching students to deal with whole problems, it is not good to throw the entire burden on them. Whole problems also may be assigned in technical courses, and should be used more extensively than they usually are at present. A given situation may be used as either a fragmentary or a whole problem; for example consider a simple electric circuit consisting of a battery connected through a switch to a resistor and condenser in series. If the assign-

ment consists of finding the condenser voltage as a function of time, the task is essentially routine; no decisions of importance have to be made; and the value of the problem lies chiefly in its emphasis on the third and fourth stages of the method, executing a plan of solution, which in this case is predetermined, and checking. It is by no means valueless as an exercise, but it lacks elements that should be included in the student's training.

The very same situation may be used as the basis of a whole problem. The same circuit consisting of condenser and resistor in series can be, and is, used as an integrating circuit. When the constants are properly selected, as in many practical conditions of operation, the voltage across the condenser is the time integral of the impressed voltage. A problem may be built out of this situation by asking the student to investigate it as an integrating circuit. Then he has to decide how it is to be investigated, he has to choose the kind of impressed voltage wave, and then calculate the condenser voltage, and finally has to interpret the result in the light of his definition of the problem. The actual circuit analysis may be no different than if the problem were set in its original fragmentary form, but the kind of thinking is considerably different and the teacher finds by test that it is much more difficult for the student. The directing of attention to the possibility of improving problems in this way is one of the fruits of cross-fertilization between the humanistic-social and the scientific-technological stems.

An example of an excellent whole problem is the first problem in a course on Management of Men. The students are asked to write a letter of application for a job, the nature of which is specified. The prospective employer wants a young man who is careful and painstaking in his work and who is honest and modest, and he is to apply by letter. The employer is not a college man so that reference to courses taken, grades earned, and honor society elections will not carry much weight.

The obvious solution, in which the applicant says in his letter that he is painstaking, honest, and modest, is clearly worthless. The procedure to be followed in solving this problem is to consider carefully what qualifications and experience the applicant has that will fit him for the job, what it is the employer wants, and then to plan how to convey the relevant information in the most convincing manner. The student should make several plans and execute more than one of them completely in terms of letters. After puting them aside for several days to give him a fresh outlook free from the tension of doing the details, he should compare them carefully and select the best, or perhaps he will get new ideas and try again.

A good solution that was submitted by a student may be of interest. The student conveyed the idea that he was honest and modest by telling about a summer job he had held in a laboratory. He said that his work had been for the most part routine testing but that once in a while he was given full responsibility. He wrote the reports but they were always checked over by his immediate supervisor. By this means of telling what he did in a modest manner and refraining from an obvious opportunity to leave unqualified a statement that was true as far as it went, he gave an excellent impression of his modesty and honesty. To show that he was careful and painstaking he used the greatest care in executing the letter,

typing it neatly on a good grade of paper appropriate to his purpose, and carefully spacing it. It is perhaps needless to add that the letter was nicely phrased. In the excellence of the purely mechanical side of the letter he used means of solution which seem outside of the problem to accomplish his purpose. It is difficult to recall a purely technical problem that would be any better adapted to illustrate the handling of a whole situation in general terms.

These particular problems from the humanistic and engineering courses serve also to illustrate another sort of reciprocal relationship that may be developed between the humanistic-social and the scientific-technological stems. The definition of "work" for a high school student is a task of expressing one's technical ideas and with clarity, accuracy, and brevity, which are elements of the desired style in writing. (Other problems involving technical matters in chemistry and mathematics have been used as well.) In this way the elements of the technical courses—elementary concepts and relationships—can be brought into English or other humanistic-social courses and made a part of them. The reciprocal relationship, the bringing of English, for instance, into the technical courses, is equally desirable. All of the written exercises in technical courses should be judged not only by numerical accuracy, but in terms of clarity and neatness as well. Problem solutions that consist merely of an aggregation of equations should not be acceptable, nor should laboratory reports that ramble on and on, telling nothing of interest to either teacher or student and yet giving an unjustified feeling of having fulfilled the requirements. Furthermore, the emphasis on writing and style in technical courses should be carried to the point of basing the grade upon them as well as upon the technical requirement.

Let us turn to the implication of the foregoing discussion in the actual planning of the humanistic-social program for engineering students. It implies that to get the real value out of the program it is more important to plan how the subject will be treated than to plan what subjects of instruction will be given and what topics are included in each course. The social relations program at Carnegie Institute of Technology consists of six credit hours of English and four of history in the freshman year, three of history and three of economics in the sophomore year, three of psychology and three of either English literature or art or music in the junior year, and six credit hours of a two semester sequence in the senior year, which will carry the student to an advanced level in one field such as history or economics or psychology.

But this is not the significant thing. In fact it is not even significant that in the first history course three weeks are devoted to biological, anthropological and sociological concepts and principles, five weeks to the Neolithic Age, and seven weeks to the decline of the Roman Republic, or that other courses have their own particular outlines. The significant thing is how the course is taught, that the work centers around problems, that the discussions involve the treatment of problems with engineering orderliness of thought, and that the student is taught the art of generalizing from experience. There might also be added the fact that he is expected to work as hard in his humanistic-social studies as in the technical ones and also is assigned at least

one written exercise a week in which he is judged, in courses other than English, on the clarity and accuracy of his thought and expression. The planning of the humanistic-social program, at least as we conceive it, is thus a matter that concerns the inside of the course rather than its name and outline. Planning is a matter of how the subject is taught rather than what is taught.

But this still does not tell how to get from the plan to the teaching. A valuable procedure that we have adopted makes use of experimental or "pilot' courses. Like the small pilot plant that precedes the construction of the big prototype, a few sections of a big course in history or any one of the humanistic-social courses are put into the hands of an instructor qualified to develop them to the fulfillment of the ends I have discussed. He defines for himself how to relate the goals of his particular course to those of the curriculum, chooses the topics to be treated and plans the treatment, devises the problems and tests his procedure by trying it out. It is in fact a large scale adaptation of the approach to problems: definition, planning, execution, checking and learning.

This instructor's load is reduced to permit his spending more time in developing the course and on the grading of assigned papers. Also he is in frequent consultation with others working on related courses. Last semester there were regular meetings every two weeks of all teachers responsible for experimental courses and in between these meetings informal conferences by pairs and threes. Over a period of time a course grows, and with it the teacher. New teachers are added to the group teaching the pilot courses and they learn as apprentices.

The new techniques are passed on and further developed, and the number of teachers participating grows without dilution of the clarity with which the goals are understood, until eventually all of the humanistic-social work will be taught to engineering students in this most fruitful manner.

Thus the planning of the humanistic-social program is primarily a planning of how to treat rather than what to treat. By insisting that the humanistic-social studies develop engineering orderliness of thought, analytical power, and scholarly attitude the engineering schools have the opportunity to make an outstanding contribution to education, particularly on the cultural side. They more than any other schools are aware that, as the Greek derivation indicates, culture means fundamental discipline of the mind, and they are in a position to insist that academic courses be taught so as to give a cultivation of mind and spirit that extends beyond the sterilizing confines of subject matter. Such cultivation of mind means that the student will never be too old to learn. Throughout life he will grow in stature because he has been taught the art and has discovered the thrill of learning from experience.

Technical Institute Survey

A second "Annual Survey of Technical Institutes" has been prepared by Leo F. Smith, Chairman, Educational Research Office, Rochester Institute of Technology. This survey, which appeared in the June, 1946, issue of *Technical Education News* published by McGraw-Hill Book Company, presents data concerning enrollments in nondegree granting technical institutes as of January 2, 1946.

In making the survey a year ago, Mr. Smith utilized as a starting point the following: (1) The survey made under the sponsorship of the Society for the Promotion of Engineering Education in 1931; (2) the intensive study made by the committee working with Dr. Lynn Emerson and published as *Vocational-Technical Training for Industrial Occupations;* (3) a list that had been prepared under the direction of Dean H. P. Hammond, chairman of the Engineers' Council for Professional Development committee on the accrediting of technical institutes; and (4) suggestions made by Edward E. Booher, vice-president of McGraw-Hill Book Company, Inc.

At present all of the schools that had responded to the initial survey plus those which had written in during the year stating that they believed they belonged in a survey of this kind are scheduled. The definition that was used again this year was adapted from the one prepared by Dean Hammond's committee of the E.C.P.D. and is as follows:

"Technical institute programs are essentially technological in nature and intermediate between those of the high school and the vocational school on the one hand and the engineering college on the other. Curriculums in this field are offered by a variety of institutions and cover a considerable range as to duration and content of subject matter, but have in common the following purposes and characteristics:

1. The purpose is to prepare individuals for positions auxiliary to, but not in, the field of professional engineering.
2. Curriculums are essentially technological in nature, are based upon principles of science, require the use of mathematics beyond high school and emphasize rational processes rather than rules of practice.
3. Curriculums are briefer, more intensive, and more specific in purpose than collegiate engineering curriculums, although they lie in the same general fields of industry and engineering. Their aim is to prepare individuals for specific technical positions or lines of activity rather than for broad sectors of engineering practice.
4. Training for artisanship is not included within the scope of education of technical institute type.
5. High-school graduation or the equivalent is required for admission."

To simplify the collection and compilation of data, institutes were classified according to type or control as follows: State maritime academies and federal schools; state and municipal technical institutes; proprietary technical institutes; privately endowed

technical institutes; and Y.M.C.A. schools. No attempt was made to survey the industrial training programs or the extension division courses offered by colleges and universities to see if they satisfied the definition that had been utilized. Similarly, no attempt was made to survey the terminal curriculums in junior colleges as information was received that such a study is now being planned under the direction of the American Association of Junior Colleges. During the present survey, questionnaires were mailed to 88 technical institutes and replies received from 74.

The data regarding enrollment in the state and municipal, privately endowed, proprietary, Y.M.C.A. schools, and state maritime academies and federal schools revealed that for the schools reporting there were 8,520 regular day civilian students enrolled as of Jan. 2, 1946. In addition, there were 7,879 special and evening-school students, making a total of 16,399. The 8,520 regular students during the current school year compare with 10,265 and 3,249 regular students enrolled in 1940–1941 and 1944–1945, respectively. These figures are not directly comparable, however, as several schools that reported relatively large enrollments in the earlier years did not respond to the present survey. Similarly, several schools are included in the present survey that were not included in the initial survey.

In addition to the civilian enrollment, 2,257 students were enrolled in the maritime academies and federal schools. This compares with 5,550 reported enrolled during 1944–1945.

Certain data regarding the state maritime academies and federal schools in the technical institute category are shown. The large reduction in numbers reported is due to the curtailment of the training program in the U. S. Maritime Service officer's schools, and the fact that the U. S. Merchant Marine Cadet Corps has lengthened the course of study to four years and the course is being revised to meet collegiate standards.

The data concerning the state and municipal technical institutes show that the regular day enrollment in the institutes reporting total 1,837, which compares with a regular enrollment of 2,539 in 1940–1941, and 851 in 1944–1945.

The Milwaukee Vocational School is not one institute but several different schools grouped in one. The enrollment reported is for the evening technical engineering division, which provides courses for five years beyond high school.

On April 6 Governor Dewey of New York signed a bill providing for the establishment, on an experimental basis, of five technical institutes to be operated entirely at state expense for five years. These institutes will be in addition to the state agricultural and technical institutes at Alfred, Canton, Cobleskill, Delhi, Farmingdale, and Morrisville. It is estimated that they will care for 4,500 full-time and 9,000 part-time students.

The State of Connecticut is also in the process of establishing engineering institutes to provide two years of post-secondary school study in the engineering fields.

State schools that have active programs under way are Purdue University, The Pennsylvania State College, Rhode Island State College, and the University of Minnesota.

The information received from the privately endowed technical institutes shows that the day enrollment of 4,206

compares with a regular enrollment of 2,571 in 1940–1941 and 644 in 1944–1945.

Franklin Technical Institute reports that it has recently been examined by the E.C.P.D. committee working under the chairmanship of Dean Hammond. It is interesting to note that although this institute is privately endowed it is publicly controlled.

The Rochester Institute of Technology has a $750,000 three-story building under construction that will be ready for occupancy in September, 1946, and make possible the expansion of enrollment from a former day-school capacity of 850 to approximately 1,300.

The Hancock College of Aeronautics, which was listed as a proprietary institution in last year's survey, was rededicated November 1, 1945, as the University of Southern California College of Aeronautics. At present it offers courses primarily in the technical institute field.

The answers received from the proprietary technical institutes indicate that the regular day enrollment for those schools reporting is 5,663. This compares with 5,155 students reported in 1940–1941 and 1,754 students in 1944–1945. These figures are not directly comparable, however, as several of the schools that reported relatively large enrollments in the earlier years did not respond to the present survey. Several of these institutes that were training large numbers of men for the Armed Forces during the war were in the process of reconverting to take care of the civilian and veteran students when the present survey was made.

The data obtained from the Y.M.C.A. schools that responded to this survey reveal that a total of only 150 regular day students was reported in technical institute courses.

As a result of having completed two surveys, certain generalizations are drawn. These are as follows:

1. It is apparent that some type of annual survey of technical institutes should be continued. By and large, educators in American higher institutions know very little about the number, purpose, and function of technical institutes. For example, in the excellent survey that Dr. Carter V. Good completed for the American Council on Education and that the Council has just published as *A Guide to Colleges, Universities, and Professional Schools in the United States* the great majority of all of the colleges, universities, and junior colleges are included. Only a few of the technical institutes have been included. This is in no sense a criticism of the work that has been done but again indicates the lack of knowledge that people have concerning technical institutes.

2. Additional thought needs to be given to the definition that has been utilized. It is unfortunate that the present definition, if strictly applied, rules out enrollments in numerous curriculums that are integral parts of some of the technical institutes.

3. It has been suggested that the terminal courses in junior colleges should be included in such a survey. Inasmuch as the American Association of Junior Colleges is now planning such a study there seems to be no reason for duplicating the work of that association.

4. Enrollment in these institutions, like all higher institutions, is rapidly on the increase, as is indicated by the total number of 8,520 regular civilian students reported this year as compared with 3,249 reported a year ago.

Footnote and Fancy Free

By JOHN A. WALTER
University of Texas

The teacher of undergraduate courses in writing is expected by all except the brighter students to supply formulas for all writing problems. Particularly in courses in technical writing, since great stress is placed on correctness of form and procedure, is he expected to provide patterns which will insure success to the student who sedulously follows them. And, despite the fact that a sensible teacher realizes the impossibility of substituting rules, formulas, and patterns for intelligent adaptability on the part of the writer, he is desirous of giving his students a usable, adequate operating procedure that will serve them in dealing with most writing problems.

Since rules are simply generalizations deduced from observation of accepted usage, the teacher ordinarily experiences no serious difficulty in providing them for his students. However, when he seeks for agreement concerning the details of documentary form and procedure in engineering and scientific journals, he fails completely. He finds that there are no widely accepted practices in presenting bibliographical data. In fact, he comes upon such a variety of forms and practices that he is unable to say anything constructively positive at all to his students. He is tempted to tell them that any method is acceptable as long as it presents a certain amount of information, for each periodical utilizes a form of its own and each is radically, in a number of respects, different from any of the others.

This fruitless search for "rules" was conducted through a dozen well-known periodicals, and it is interesting to take note of some of the varied forms and practices used for listing cited literature.

First, there is a divergence of opinion concerning the importance of the author of an article. Half of the journals examined place his name first in a footnoted reference or bibliographical entry, before the title of his article; half place it after. Some place his given names or initials before his name, some after. Some use the word "by" to introduce his name while still others do not. One journal places the author's name after the title of his work, but puts it in bold face type.

Second, there is the title itself. Obviously, in view of what has just been said, there is considerable difference of opinion as to whether it should appear as the first or second element in the note, but there are other interesting, one might almost say quaint, usages. For instance, some journals omit the title of an author's article, giving only his name and the periodical title in which the article appeared. Though a majority of the periodicals examined follow what is be-

lieved to be the commonly accepted practice of placing the titles of articles in quotation marks, there are some curious variations. One magazine uses neither quotes nor italics; another prints titles in small capitals; still another uses both quotation marks and italics! Some of the magazines which use quotation marks for titles of articles also use them for book titles, rather than the customary italics. One journal, apparently taking no chances, uses neither quotation marks nor italics, but places the identifying word "book" in parentheses just after the title.

Third, there are the methods of recording data about volume and page numbers of books and periodicals. These methods include spelling out the word "volume"; abbreviating it, sometimes in lower case letters, sometimes in capitals; and omitting it, using bold face type for the figure. Some journals spell out "page" before the actual figures, some abbreviate the word (p. and pg.), and some omit it entirely.

Fourth are the styles of presenting publishing data. In some cases the publishing firm of a book is given in parentheses; in others without. Sometimes the place of publication is given, sometimes not. The date of publication may be found enclosed in parentheses, without parentheses, or not at all. But a majority of the periodicals place the publisher's name first, followed by the place of publication and the date of publication, the items being separated by commas. Only occasionally does one find the place of publication preceding the firm's name, separated by a colon.

Fifth, there are some miscellaneous details. The reference numbers themselves in the text are sometimes placed exponentially, sometimes enclosed in parentheses (without being raised above the level of the line); sometimes a smaller type is used for these numbers, sometimes not; and occasionally the numbers are followed by a period. A few of the journals indent a few spaces before printing the number; many place it flush with the margin, but there are those which favor hanging indentation for subsequent lines; still others print the number flush with the margin and begin subsequent lines just under the first word of the first line, thus giving the number special prominence. In punctuating the entry as a whole, some journals favor the comma between the main elements (author, title, publishing data); some prefer periods. The variation of practice regarding the use of abbreviations is extreme, too extreme to describe in this short note. There is one point, however, on which a majority agree: footnotes or references are most often placed at the end of the article rather than at the foot of the page.

The facts here presented make it obvious that the search for common practices in this field on which to base "rules" has been unrewarding. Such an examination leads a teacher to no useful conclusions at all, unless he, for one reason or another, feels that one or another of the journals is more to be respected and depended upon than the others, but the members of the various engineering societies would not likely agree with any such choice. It may be argued that these divergent practices are all perfectly justifiable and that it makes no significant difference what manner of presenting such data is chosen as long as the data are given. It may be further urged, and persuasively, that a bibliographical entry is unimportant in itself and is given, after all, simply as a conveni-

ence to the curious reader. But these very arguments serve rather to support than to deny a plea for standardization of practice. Since the important thing is to provide enough information about a source so that it may be easily found by a reader, nothing is gained by having such an abundance of forms. On the contrary, it would be a convenience to all—teachers of technical writing, engineers, scientists, and publishers—if one form were acceptable to all. It has been found advisable to standardize technical abbreviations; why not standardize bibliographical forms?

Periodicals examined:

Scientific Monthly
Electrical Engineering
Technology Review
Civil Engineering
Agricultural Engineering
Petroleum Engineering
Industrial and Engineering Chemistry
Journal of Applied Mechanics
Structural Engineer
Mechanical Engineering
Science
American Scientist

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GAY, NORMAN R., Assistant Professor of Heat-Power. F. O. Ellenwood, B. J. Conta.

JEFFREY, JOSEPH O., Professor of Engineering Materials. J. R. Moynihan, H. H. Mabie.

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DODDS, ROBERT H., Associate Professor of Civil Engineering, Colorado A. & M. College, Fort Collins, Colo. E. E. Johnson, R. L. Lewis.

EVANS, WALTER R., Instructor in Electrical Engineering, Washington University, St. Louis, Mo. R. S. Glasgow, A. S. Langsdorf.

FORSTER, GEORGE, Teacher of Engineering Physics, Pasadena Junior College, Pasadena, Calif. A. G. Gehrig, W. L. Johnson.

GILDEA, ROBERT E. L., Associate Professor of Civil Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

GONZALES-RUBIO, ELBERTA, JR., Instructor in Architecture, Georgia School of Technology, Atlanta, Ga. J. J. Pollard, T. H. Evans.

GUNNESS, CHRISTIAN I., Professor of Agricultural Engineering, Massachusetts State College, Amherst, Mass. G. A. Marston, C. E. Tucker.

HARRY, CHARLES M., Instructor in Mining, Michigan College M. & T., Houghton, Mich.

HENRY, LAWRENCE O., Instructor in Civil Engineering, North Dakota State College, Fargo, N. D. H. S. Dixon, R. M. Dolve,

HEUER, WM. EMIL, Associate Professor of Mechanical Engineering, University of Toledo, Toledo, Ohio. J. B. Brandeberry, W. S. Smith.

HORWOOD, EDGAR M., Acting Instructor in Civil Engineering, Washington University, Seattle, Wash. E. R. Wilcox, C. E. Douglass.

HUBBARD, ROBERT M., Associate Professor of Chemical Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

HUNSAKER, JEROME C., Professor of Mechanical Engineering, Massachusetts Inst. Tech., Cambridge, Mass. C. E. Tucker, H. L. Hazen.

KAUFMAN, SIDNEY, Administrative Officer, Army Air Forces Inst. Tech., Wright Field, Ohio. C. R. Wylie, Ezra Kotcher.

KINNIER, HENRY L., Acting Professor of Civil Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

KISHIBAY, CHARLES O., Instructor in Physics, Pratt Inst., New York City. R. E. Lake, A. W. Doll.

LAMB, GEORGE G., Professor of Chemical Engineering, Northwestern University, Evanston, Ill. O. W. Eshbach, P. E. Klopsteg.

LAUSHEY, LOUIS M., Instructor in Civil Engineering, Carnegie Inst. Tech., Pittsburgh, Pa. F. T. Mavis, J. W. Graham.

MCCORMACK, JOHN T., Instructor in Geology, Purdue University, Lafayette, Ind. F. L. Serviss, B. N. Shreve.

LEWIS, IRWIN M., Instructor in Mechanical Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

MACCONOCHIE, ARTHUR F., Professor of Mechanical Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

MAY, JAMES E., Assistant Professor of Mechanical Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

MCMILLAN, CLAUDE R., Instructor in Civil Engineering, University of South Carolina, Columbia, S. C. J. W. Linden, R. L. Sumwalt.

MILLER, JAMES S., Professor of Electrical Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

MITTET, HOLGER P., Instructor in Civil Engineering, University of Washington, Seattle, Wash. E. R. Wilcox, C. E. Douglass.

MOORE, VINCENT J., Instructor in Mathematics, University of Colorado, Boulder, Colo. C. A. Hutchison, Warren Raeder.

MORSE, FREDERICK T., Professor of Mechanical Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

MOSES, ROBERT G., Instructor in Engineering, Pasadena Junior College, Pasadena, Calif. W. L. Johnson, A. G. Gehrig.

MULLEE, WILLIAM R., Professor of Administrative Engineering, New York University, New York City. D. B. Porter, F. L. Bishop.

NELSON, WALTER K., Associate Professor of Mathematics, University of Colorado, Boulder, Colo. C. A. Hutchison, Warren Raeder.

NEWTON, ROBERT E., Assistant Professor of Applied Mechanics, Washington Univ., St. Louis, Mo. R. R. Middlemiss, A. S. Langsdorf.

PANKRATZ, GEORGE E., Assistant Professor of Engineering Drawing, University of Toledo, Toledo, Ohio. J. B. Brandeberry, W. S. Smith.

PARKER, BEN H., President, Colorado School of Mines, Golden, Colo. M. F. Coolbaugh, H. M. Crane.

PENICK, JOHN M., Associate Professor of Industrial Engineering, Texas Tech. College, Lubbock, Texas. O. A. St. Clair, O. V. Adams.

RIDDELL, JOSEPH M., Professor and Head, Dept. Mining Engineering, Michigan College M. & T., Houghton, Mich. E. P. Friedenbarger, W. C. Polkinghorne.

RUSSELL, RALSTON, Professor of Ceramic Engineering, Ohio State University, Columbus, Ohio. J. L. Carruthers, R. M. King.

RYAN, PHILIP H., Lecturer in Mathematics, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

SANDER, JOHN L., Instructor in Drawing, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

SMITH, DONALD E., Secretary-Treasurer, Alumni Association, Worcester Poly. Inst., Worcester, Mass. A. J. Knight, J. W. Howe.

SPENNER, FRANK J., 501 Prospect St., Trinidad, Colo. F. L. Bishop, Nell McKenry.

SWENSON, JOHN D., Assistant Professor of Civil Engineering Massachusetts State College, Amherst, Mass. G. A. Marston, C. E. Tucker.

TESS, PAUL J., Assistant Professor of Mechanical Engineering, University of Toledo, Toledo, Ohio. W. S. Smith, J. B. Brandeberry.

THOMAS, CLARENCE D., Associate Professor of Physics, University of Tulsa, Tulsa, Okla. R. L. Langenheim, D. R. Shreve.

TICHVINSKY, LEONID M., Associate Professor of Mechanical Engineering, Washington University, St. Louis, Mo. S. H. Van Wambeck, A. S. Langsdorf.

TOVANI, ERNEST P., Assistant Professor, University of Colorado, Boulder, Colo. Warren Raeder, C. A. Hutchison.

TRESE, RALPH E., Assistant Professor of Engineering, University of Toledo, Toledo, Ohio. J. B. Brandeberry, W. S. Smith.

UPDIKE, OTIS L., Associate Professor of Chemical Engineering, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

WHITE, EDWARD L., Associate Professor of Engineering; Director VPI Extension at Norfolk, Va. R. B. H. Begg, F. C. Morris.

WILCOX, ALFRED C., Teacher of Engineering, Pasadena Junior College, Pasadena, Calif. A. G. Gehrig, W. L. Johnson.

WILE, HOWARD P., Administrator of Research, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. H. S. Rogers, C. Wandmacher.

WILLARD, FREDERICK R., Instructor in Electrical Engineering, North Carolina State College, Raleigh, N C. R. S. Fouraker, W. D. Stevenson.

WILLIAMS, CLIFFORD D., Head Professor of Civil Engineering, University of Florida, Gainesville, Fla. Joseph Weil, N. C. Ebaugh.

WILLIAMS, EDGAR M., Lecturer in English, University of Virginia, University, Va. W. S. Rodman, J. L. Vaughan.

WILSON, CLAUDE L., Director of Mechanic Arts, Prairie View University, Prairie View, Texas. A. R. McCollum, N. D. Durland.

73 applicants + 213 elected = 286 new members this year

Sections and Branches

The **Missouri Section** of A.S.E.E. held its first meeting in three years at Rolla, Missouri on October 26 with the Missouri School of Mines and Metallurgy as host. Professor H. W. Wood, Jr. of the University of Missouri presided at the general meeting in the morning and at the dinner meeting in the evening. The afternoon program consisted of group conferences by the divisions of Engineering Drawing, Civil, Chemical, Electrical, and Mechanical Engineering. Three of the groups had a presentation of prepared papers, while the Electrical and Mechanical Engineering groups used the medium of an open discussion for an exchange of ideas.

At the evening dinner we were favored by the presence of President Huber O. Croft of the State University of Iowa who delivered a talk on "Scientists, Engineers and Peace."

New officers were elected as follows: President, S. H. Van Wambeck, Washington University, St. Louis, Missouri; Vice-President, Dean Curtis L. Wilson, Missouri School of Mines, Rolla, Missouri; Secretary, Professor Donald L. Weidelich, University of Missouri, Columbia, Missouri; Counsel Member (to take office in July, 1947), S. H. Van Wambeck, Washington University, St. Louis, Missouri.

S. H. VAN WAMBECK,
President of Missouri Section

The fall meeting of the **New England Section** of the American Society for Engineering Education was held at Norwich University on Saturday, October 5, 1946. The total registration was 235 members and guests.

The following morning conferences were held:

A. *Chemical Engineering*—attendance 12.

Chairman: Professor Ernest D. Wilson, Worcester Polytechnic Institute.

10:00 Subject: "Chemical Engineering in the Post-War Curriculum."

Speaker: President Wat Tyler Cluverius, Worcester Polytechnic Institute.

10:30 Subject: "The Teaching of Thermodynamics in the Chemical Engineering Curriculum."

Speakers: Professors Barnett F. Dodge and R. Harding Bliss, Yale University.

11:00 Subject: "The Teaching of Instrumentation in the Chemical Engineering Curriculum."

Speaker: Professor John M. Petrie, Worcester Polytechnic Institute.

11:30 Subject: "The Pros and Cons of a Five-Year Chemical Engineering Program."

Speaker: Dean T. Stephen Crawford, R. I. State College.

Discussion: Professor Chester P. Baker, Northeastern University; Dean Thomas K. Sherwood, M. I. T.

B. *Civil Engineering*—attendance 27.

Chairman: Professor John B. Wilbur, Massachusetts Institute of Technology.

Theme: "Is Civil Engineering Attracting High Caliber Students?"

10:00 Subject: "The Influence of Recent World Developments."
Speaker: Mr. Oliver G. Julian, Jackson and Moreland.
10:30 Subject: "The Influence of the Curriculum and Opportunity for Employment."
Speaker: Professor Gordon M. Fair, Harvard University.
11:00 Subject: "The Influence of the Teacher."
Speaker: Professor Emil A. Gramstorff, Northeastern University.

C. *Drawing*—attendance 24.
Chairman: Professor Douglas P. Adams, Massachusetts Institute of Technology.
10:00 Subject: "Graphical and Analytic Methods as Applied to Aircraft Design."
Speaker: Mr. Steven Anson Coons, Chance Vought Aircraft Company.
11:00 Subject: "New Magic in Old Lines."
Speaker: Mr. Achille Presuitti, Jackson and Moreland.
11:45 Subject: "The New Standards of Engineering Drawing Symbols—Origin and Significance."
Speaker: Professor Harry M. McCully, Carnegie Institute of Technology.

D. *Electrical Engineering*—attendance 28.
Chairman: Professor Laurence F. Cleveland, Northeastern University.
10:00 Subject: "Training of Electrical Engineering Students for Post-War Industry."
Speaker: Mr. J. C. McKeon, Westinghouse Electric Corporation.
11:00 Subject: "The Place of Servomechanisms in Electrical Engineering Undergraduate Program."
Speaker: Dr. Gordon S. Brown, Massachusetts Institute of Technology.

E. *Engineering School Libraries*—attendance 10.
Chairman: Miss Natalie Nicholson, Harvard University.
10:00 Subject "The Mechanical Engineering Library Collection—a Survey and Appraisal."
Speaker: Mr. John B. O'Farrell, City College of New York.
11:00 Discussion: "Occupational Information in the Library—Sources, Arrangement and Use."
Leader: Mr. Francis P. Allen, Rhode Island State College.

F. *English and Humanities*—attendance 11.
Chairman: Professor Edwin Higginbottom, Worcester Polytechnic Institute.
10:00 Subject: "The Engineering Student and Literature."
Speaker: Professor William F. Scammon, Maine.
10:30 Subject: "Aims and Content of a Course in Literature for Engineers."
Speaker: Professor Lee C. Wilson, Rhode Island State College.
11:00 Subject: "Integration of the Humanities and Social Sciences."
Speaker: Professor H. R. Bartlett, Massachusetts Institute of Technology.

G. *Mathematics*—attendance 12.
Chairman: Professor L. E. Dix, Norwich University.

10:00 Subject: "Instruction in Mathematics for the Returning Veteran."
General Discussion.
11:00 Subject: "Non-Linear Problems in Engineering."
Speaker: Professor Jules A. Larrivee, Vermont.

H. *Mechanical Engineering*—attendance 27.
Chairman: Professor J. W. Zeller, Northeastern University.
10:00 Subject: "Mechanical Laboratory Instruments."
Speaker: Professor James Holt, Massachusetts Institute of Technology.
11:00 Subject: "College Machine Design for Industry."
Speaker: Professor Alexander W. Luce, Pratt Institute.

I. *Mechanics, Strength of Materials and Fluid Mechanics*—attendance 18.
Chairman: Professor Earle F. Littleton, Tufts College.
10:00 Subject: "Rockets as Vehicles for Explanation of Mechanical Principles to Undergraduates."
Speaker: Professor J. P. Den Hartog, Massachusetts Institute of Technology.
11:00 Subject: "The Theory of Flexure."
Speaker: Professor Hardy Cross, Yale University.

J. *Physics*—attendance 18.
Chairman: Professor C. E. Bennett, Maine.
10:00 Subject: "Engineering Physics—Introductory Remarks."
Speaker: President Homer L. Dodge, Norwich University.
11:00 Subject: "Engineering Physics—Curriculum Problems."
Speaker: Professor Joseph C. Boyce, New York University.

Professor G. A. Marston of Massachusetts State College presented an invitation from President Baker to the Section to hold its 1947 meeting at Amherst. The chairman asked for an informal expression of opinion as to the acceptance of the invitation. Almost unanimous approval was indicated.

The afternoon meeting was held in the Armory with an attendance of 106 and the following program.

Subject: "The Engineering Schools and the U. S. Office of Education."
Speaker: Dr. Henry H. Armsby, Specialist in Engineering Education—U. S. Office of Education.
Subject: "The Influence of Industrial Research on Engineering Education."
Speaker: Dr. Frank B. Jewett, President, National Academy of Sciences.

The annual dinner was held at 6:30 p.m. in White Hall with an attendance of 209. Following the dinner a brief business meeting was held with Chairman Dawes presiding. In accordance with custom the secretary read the Constitution of the Section, spoke of the work on revision of the Constitution of the National Society, and gave the scores of the football games of the day. He also noted that this meeting constituted the twenty-fifth anniversary of the founding of the Section. He told of the inauguration of the Program Committee with one representative from each institution and commented on the faithfulness with which the various members attended the meetings held during the winter and spring to plan the fall meeting.

Professor R. G. Porter presented a report of the Nominating Committee in which Professor C. E. Tucker was nominated for Chairman, Mr. W. E. Keith for Secretary, and Professor C. L. Dawes for Sectional representative on the Council of the National Society for one year. No additional nominees being presented, the slate was put to vote and the nominees duly elected.

Professor T. H. Morgan, chairman of the Resolutions Committee, was then called on and presented the following resolutions which were unanimously accepted by the Section:

"On behalf of the members of the New England Section your Resolutions Committee wishes to express sincere gratitude to all who contributed to the success of our meetings today. It has been a most pleasant and profitable one. While Nature has been remarkably cooperative and it is a special privilege to be in Vermont in early October, we know that such a successful meeting as this one can result only from a vast amount of work on the part of those who must make the necessary arrangements.

"In particular your Committee wishes to express appreciation of the hospitality of Norwich University and of both President and Mrs. Homer L. Dodge. We wish to thank Professor Douglas E. Howes and the members of the local committees who so thoughtfully arranged for the stimulating and pleasant activities of the day, and Mrs. Spencer and her committee for arranging the ladies' program. We are grateful to Mr. Marshall Arlin and his committee for preparing the original and interesting *News Bulletin*, and to Chairman Chester L. Dawes and Secretary Carlton E. Tucker for their arduous work in planning and guiding the meeting."

Signed: Resolutions Committee:
H. R. BARTLETT
T. B. MORGAN

Professor Dawes then introduced President H. L. Dodge. Dr. Dodge gave a very fascinating talk on "A Pack Trip in the High Rockies" illustrated by Kodachrome film slides. The pictures were taken by Dr. Dodge and illustrated one of the most colorful sections of the Rocky Mountains.

Attending the convention were 71 visiting ladies who were entertained by a committee under the chairmanship of Mrs. F. A. Spencer. During the morning the ladies enjoyed a guided tour of the state house at Montpelier, visiting the historical rooms. At 1 o'clock they enjoyed luncheon at the Montpelier Tavern, and from 3 to 5 in the afternoon were entertained at tea by Mrs. Homer L. Dodge at the President's home in Northfield. They joined the men for dinner in the evening.

The financial report through October 28, 1946 is submitted herewith.

NEW ENGLAND SECTION, A.S.E.E.

Financial Report, 1944–46

Balance, October 24, 1944	$13.36
December 13, 1944—Additional Receipts from Harvard meeting	8.00
Interest	.26
Receipts from 1946 Fall meeting	34.70
	$56.32

Expenditures

Telephone	$ 1.56
Mimeograph	7.19
Envelopes and postage	18.56
Printing of programs	27.75
Balance October 28, 1946	1.26
	$56.32

Respectfully submitted,
CARLTON E. TUCKER, *Secretary*

College Notes

On October 3 and 4, 1946 the **University of Buffalo** celebrated the hundredth anniversary of its founding. There were 196 delegates from England, France and the States. The oldest institution represented was the University of Glasgow, founded in 1451, and the youngest, Iona College, 1940. The American Society for Engineering Education was represented by Paul H. Black who is chairman of the Upper New York Section.

A high point of the celebration was the dedication of the new engineering building and the handing over of the keys to the building to Dean Paul E. Mohn. The school conducts four-year courses in mechanical engineering and in industrial engineering, the latter headed by Professor F. H. Thomas. Some work is offered in electrical, civil and chemical engineering as well. A four-year course in electrical engineering and graduate work in engineering are contemplated.

An academic convocation commemorating the Seventy-Fifth Anniversary of the **Missouri School of Mines and Metallurgy** was held recently in Rolla, Missouri. Dr. Frederick A. Middlebush, President of the University of Missouri, presided at the convocation, and Dr. Eugene McAuliffe, Chairman, Board of Trustees, Union Pacific Coal Company, delivered the principal address on "The Engineer's Contribution to Society and the World." Honorary degrees were conferred upon James Presley Gill, Vice President of the Vanadium Alloys Steel Company, and Herbert Russell Hanley, Professor Emeritus of Metallurgical Engineering at the Missouri School of Mines and Metallurgy.

Since the formal opening of the Missouri School of Mines and Metallurgy on "Dedication Day," November 23, 1871, the school has expanded from an institution with one building, two faculty members, and 28 students, to a modern school of technology valued at more than $3,000,000, having more than 100 faculty members and an enrollment of approximately 2200. Established and maintained jointly by the State of Missouri and the Federal Government under the provisions of the Morrill Act of 1862, the Missouri School of Mines and Metallurgy has provided technical and scientific education to more than 10,000 students coming from every state in America and many foreign countries. By maintaining seven major departments, the school now grants degrees in Science and Ceramic, Chemical, Civil, Electrical, Mechanical, Metallurgical, and Mining Engineering. It also has scientific and service departments which include Humanities and Social Studies, Engineering Drawing, Geology and Mineralogy, Mathematics, Mechanics, Military Science and Tactics, Physical Education, and Physics.

Physics Column

Attention is called to several recent announcements of physics curricula of the type classified as engineering physics in the report published by the committee on Engineering Physics of the Physics Division.* At the University of Wisconsin, Professor L. R. Ingersoll reports on the new Physics option in Engineering corresponding to a short curriculum in engineering physics.

Harvard University has recently announced a new curriculum in Applied Physics and Engineering Science.

Cornell University inagurated a curriculum called Engineering Physics this summer. Along with the other engineering curricula at Cornell this is a five year program.

Among items of interest to physicists is news of the conference on Engineering Physics held as part of the fall meeting of the New England Section A.S.E.E. on Oct. 5, 1946 at Norwich University, at which the present writer of this column presided. Speakers included Professor Joseph C. Boyce, New York University, President Homer L. Dodge, Norwich University, and Dr. Frank B. Jewett, President, National Academy of Sciences.

This column affords a real opportunity for physicists to keep posted on the activities of their colleagues, but its usefulness depends directly upon the interest shown by the members in sending in news items. Such items should be sent to C. E. Bennett (Univ. of Maine), chairman, or J. H. Howey (Georgia Inst. of Tech.), secretary, of the Division.

C. E. BENNETT, *Chairman,*
Physics Division A.S.E.E.

* JOURN. OF ENG. ED., Vol. 36, No. 7, March, 1946.

Return to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh 13, Pa.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Date .....

I desire to become a member of the
AMERICAN SOCIETY FOR ENGINEERING EDUCATION
and hereby agree to conform to the requirements of membership, if elected, and submit the following

STATEMENT OF QUALIFICATIONS:

Full Christian Name and Surname .....
PRINT LAST NAME FIRST MIDDLE

Mailing Address (Number and Street) .....

Post Office (City and State) .....

Full Title of Professional Position .....
(TITLE) (DEPARTMENT)

Full Name of Institution .....

(To be signed by Two Sponsors)

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